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Frenchman Dam, Phillips County, Montana, MT-3

PHASE I - INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

27

FRENCHMAN DAM
PHILLIPS COUNTY, MONTANA
MT - 3

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FRENCHMAN WATER USERS ASSOCIATION
OPERATOR

PREPARED BY:

Christian, Spring, Sielbach & Associates
Bozeman, Montana

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Assisted By:

Northern Testing Labs, Inc.
Great Falls, Montana

AUGUST 1981

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EXECUTIVE SUMMARY

Personnel of Christian, Spring, Sielbach & Associates, principal contractor, and Northern Testing Laboratories, Inc., subcontractors, under a contract with the Montana Department of Natural Resources and Conservation (MDNRC) and with representation from the MDNRC and the Water Users Association, inspected the Frenchman Dam on March 31, 1981, under the authority of Public Law 92-367. The project is located principally in Section 23, T34N, R34E, MPM, on Frenchman Creek in Phillips County, Montana, approximately 22 miles north of the town of Saco, Montana by road.

This report was compiled from information obtained during the onsite inspection and analysis of available information. Findings were compared with engineering criteria that are currently accepted by most private and public agencies engaged in dam design, construction and operation.

Findings and Evaluation

The original Frenchman Dam was constructed in 1950-51, with the Montana State Water Conservation Board (MSWCB) providing both design and construction supervision. This structure had a spillway with 4 bays for an effective crest length of 95.5 feet. On April 15, 1952 very high stream flows resulting from rapid snowmelt caused a very rapid filling of the reservoir. At about noon on April 15, a one-foot wide stream was discovered piping out of the downstream dam embankment just east of the spillway at an elevation equal to the spillway crest. The dam breached late in the afternoon and flood waters quickly eroded the earth foundation under the spillway causing it to collapse. The report on cause of failure was prepared in November, 1952, by Corps of Engineer's personnel who were eyewitnesses to the failure. There were no reports of loss of life as a result of the failure. The present rehabilitated Frenchman Dam was completed in 1953, with the MSWCB as the engineering entity responsible for design and construction. Construction plans were made available for review. The project is primarily used for storage of irrigation waters and is owned by the MDNRC and operated by the Frenchman Water Users Association.

The construction drawings identify 2 dams and 3 interconnecting dikes. For simplicity, the dam and dike embankments are referred to as the dam in this report. The portion of the right or western-most dike that has a 3.5 to 4 foot lower crest is referred to as the West Dike.

The 44-foot high dam impounds approximately 21,000 acre-feet of water at minimum dam crest elevation 2275.5 feet National Geodetic Vertical Datum (NGVD). All elevations in this report are relative to the United States Geological Survey marker, elevation 2276 feet NGVD found during the inspection on top of the spillway's east wing wall. The embankment has a structural height of 63 feet, including core trench depth and a hydraulic height of 44 feet. On the basis of criteria in the U.S. Army Corps of Engineers Recommended Guidelines for Safety Inspection of Dams (Ref. 7), the project is intermediate in size.

The sudden failure of Frenchman Dam could cause flooding of several scattered farmsteads located downstream of the dam. Several residences and buildings could be severely damaged and there is a potential for loss of life. The conclusions on probable damage are based on a brief field visit and engineering judgment. No dam breach analysis or routing of a dam breach flood was made for the project. In accordance with inspection guidelines, the project is classified as having a significant (Category 2) downstream hazard potential.

Inspection criteria (Ref. 7) recommend that an intermediate size project with a significant downstream hazard potential be capable of handling ½ the probable maximum flood (PMF) to a full PMF. The PMF is the flood expected from the most severe combination of meteorologic and hydrologic conditions that are reasonably possible in the region. The routing of the PMF from the 2,460 square mile drainage basin is complicated by 4 large reservoirs upstream that intercept runoff from almost 2/3 of the basin. A detailed analysis of these upstream reservoirs was not available and is beyond the scope of work for this inspection. Therefore, for the purpose of this limited Phase I investigation it was assumed that the four reservoirs upstream of Frenchman Dam would entirely control the flood waters from their respective drainage basins and thus not contribute to flooding at Frenchman. This assumption provides for a conservatively small flood at Frenchman Dam in that it reduces the effective drainage area from 2,460 square miles to an estimated 840 square miles. It was assumed that if Frenchman was overtopped by these conditions it would obviously be overtopped if upstream reservoirs did not control their floodwaters. Because of the involved risk, the recommended Spillway Design Flood (SDF) for Frenchman Dam is one-half of the total PMF.

The estimated PMF used for this dam safety study for the 840 square mile drainage basin was developed from a 72-hour general storm probable maximum precipitation (PMP) over the total 2,460 square mile drainage basin. The resultant PMF has an estimated volume of 345,000 acre-feet and a peak flow of 136,500 c.f.s. It was assumed the West Dike would act as an emergency spillway and for purpose of analysis, that it would withstand overtopping by the flood flows. In actuality, sustained overtopping of the West Dike would likely fail the dike and thereby increase the rate of reservoir discharge for a short period of time. The increased discharge would contribute to additional flooding downstream, however, the assessment of potential increases in damage that may be attributed to the West Dike failure is beyond the scope of work for this study. The estimated maximum capacity of the West Dike, the spillway, and the outlet works with the reservoir at minimum dam crest elevation 2275.5 feet NGVD is 36,000 c.f.s. Routing of the estimated PMF indicates that Frenchman Dam is overtopped when only 6 percent of the study PMF volume enters the reservoir. Routings of lesser hypothetical floods made by applying percentages to the PMF hydrograph ordinates, showed that a flood corresponding to 28 percent of study PMF hydrograph ordinates is just controlled by the project. The project's capability would even be less for the PMF from the entire 2,460 square mile drainage basin. The dam is constructed of materials that would erode and fail when overtopped by flood waters. Therefore, the project does not conform to inspection guideline criteria for safely passing the recommended spillway design flood.

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The visual inspection revealed no signs of cracking or unusual settlement in the dam embankment. The upstream slope has some wave erosion damage. Riprap above the water level in the reservoir (El. 2264.6 feet NGVD) at the time of inspection was scattered or non-existent on a large part of the upstream slope. The downstream slope is marked by minor erosion rills, possibly caused by livestock travel.

There is insufficient data on seepage, position of the phreatic line, and strength of embankment and foundation materials to accurately assess the stability of the embankment.

The spillway, the outlet works and the irrigation outlet all appeared to be in fair condition, (the inside of the 24-inch diameter irrigation conduit and the 60-inch diameter inlet conduit upstream from the guardian gate could not be inspected). All gates were operational and only minor concrete spalling was observed.

Recommendations

Due to storage between normal pool and dam crest, the present project provides a degree of flood protection to the downstream area. The intent of the report recommendations is to maintain or improve project safety without decreasing this existing flood protection. A downstream warning plan for use in the event of impending dam failure must be developed, tested and placed in action in the event of impending dam distress. Inspect the irrigation outlet conduits, gates and lifts, and repair if required. Repair wave erosion damage on the upstream slope and provide effective, durable riprap to protect against wave erosion. Inspect the stilling basin and repair if required.

Conduct more detailed hydrologic and hydraulic routing studies to better determine the downstream hazard and required spillway design flood. Modify the project as studies indicate. These studies should take into account the operation of upstream reservoirs and include updated reservoir storage information and estimates of usable storage depletion by sediment deposits. The studies should also consider effects of the emergency spillway erosion/failure on downstream flooding and flood routing capabilities of the project. Install piezometers and monitor to accurately determine the pore pressure distribution within the embankment. Have a qualified geotechnical engineer perform and place on file seepage and stability analysis. Develop and implement a periodic operations and maintenance program, with particular emphasis on repair and maintenance of concrete structures and conduits.

Conduct inspections of Frenchman Dam and Dike at least every 5 years by qualified engineers experienced in earth dam design, construction, operation, and maintenance.

Bob B. Gemmell

Bob B. Gemmell, P.E.

FRENCHMAN DAM
PERTINENT DATA

1. General

Federal I.D. No.	MT-3
Owner	MDNRC
Operator	Frenchman Water Users Association
Date Constructed	1951 (reconstructed 1952-1953)
Purpose	Irrigation
Location	Sec. 23, T34N, R34E, MPM 22 miles north of Saco Latitude 48°45' ±5' Longitude 107°10' ±5'
County, State	Phillips, Montana
USGS Quadrangle	Glasgow (1:250,000 scale)
Watershed	Frenchman Creek
Downstream Hazard Potential	Category 2 - Significant
Size Classification	Intermediate

2. Reservoir

Normal Pool Elevation (Spillway Crest)	2264.6 feet NGVD
Surface Area at Normal Pool	Unknown (est. 800-1,000 acres)
Drainage Area	2,460 square miles
Storage at Normal Pool	7,010 acre-feet
Storage at Minimum Dam Crest El. 2275.5 feet NGVD	21,000 acre-feet (est.)
Surcharge Storage	14,000 acre-feet

3. Spillway

Type	Reinforced concrete w/uncontrolled ogee crest
Crest Elevation	2264.6 feet NGVD
Crest Width (less bridge piers)	119 feet
Capacity with Reservoir at Minimum Dam Crest	17,500 c.f.s.

4. Low Level Outlet Works

Location	Near left abutment of Main Dam; 200 feet east of spillway
Type	60-inch diameter concrete pipe w/2 slide gates in control tower/wet well at dam crest.
Outlet Elevation	2232.7 feet NGVD
Conduit Length	230 ft.
Capacity with Reservoir at minimum dam crest	505 c.f.s.

5. Irrigation Outlet

Location	Inlet at outlet works control tower
Type	24-inch diameter RCP w/slide gate at inlet
Outlet Elevation	2254.1 feet NGVD
Conduit Length	80 ft.
Capacity with Reservoir at minimum dam crest	40 c.f.s.

FRENCHMAN DAM
PERTINENT DATA
(continued)

6. Embankments	Dam	West Dike
Type	Zoned Rolled Earth Fill	Zoned Rolled Earth Fill
Minimum Crest Elevation	2275.5 feet NGVD	2272.0 feet NGVD
Crest Length	2,100 feet	1,000 feet
Crest Width	20 feet	20 feet
Hydraulic Height	44 feet	8 feet
Structural Height	63 feet	8 feet
Upstream Slope	1V on 3H	1V on 4H
Downstream Slope	1V on 2H	1V on 2H
Discharge capacity of West Dike with Reservoir Level at Minimum Dam Crest		18,000 c.f.s.

CHAPTER 1
BACKGROUND

1.1 INTRODUCTION

1.1.2 Authority and Scope

This report summarizes the Phase I inspection and evaluation of the Frenchman Reservoir Dam (MT-3), owned by the Montana Department of Natural Resources and Conservation (MDNRC).

The National Dam Inspection Act, Public Law 92-367 dated 8 August 1972, authorized the Secretary of the Army, through the Corps of Engineers to conduct safety inspections on non-federal dams throughout the United States. Pursuant to that authority, the Chief of Engineers issued "Recommended Guidelines for Safety Inspection of Dams" in Appendix D, Volume 1 of the U.S. Army Corps of Engineers' Report to the United States Congress on "National Program of Inspection of Dams" in May, 1975 (Ref. 7).

The recommended guidelines were prepared with the help of engineers and scientists highly experienced in dam safety from many federal and state agencies, professional engineering organizations and private engineering consulting firms. Consequently, the evaluation criteria presented in the guidelines represent the comprehensive consensus of the engineering community.

Where necessary the guidelines recommend a two-phase study procedure for investigation and evaluation of existing dam conditions so deficiencies and hazardous conditions can be readily identified and corrected. The Phase I study is:

(1) a limited investigation to assess the general safety condition of the dam.
(2) based upon an evaluation of the available data and a visual inspection.
(3) performed to determine if any needed emergency measures and/or if additional studies, investigations and analyses are necessary or warranted.
(4) not intended to include extensive explorations, analysis or to provide detailed alternative correction recommendations.

The Phase II investigation includes all additional studies necessary to evaluate the safety of the dam. Included in Phase II, as required, should be additional visual inspections, measurements, foundation exploration and testing, material testing, hydraulic and hydrologic analyses and structural stability analysis.

The authority for the Corps of Engineers to participate in the inspection of non-federally owned dams is limited to Phase I investigations with the exception of situations of extreme emergency. In these cases the Corps may proceed with Phase II studies but only to the extent needed to answer serious questions relating to dam safety that cannot be answered

otherwise. The two phases of investigations outlined above are intended only to evaluate project safety and do not encompass in scope the engineering required to perform design or corrective modification work. Recommendations contained in this report may be for either Phase II safety analyses or detailed design study for corrective work.

The responsibility for implementation of these Phase I recommendations rests with the dam owner and the State of Montana. It should be noted that nothing contained in the National Dam Inspection Act, and action or failure to act under this Act shall be construed (1) to create liability in the United States or its officers or employees for the recovery of damage caused by such action or failure to act or (2) to relieve an owner or operator of a dam of the legal duties, obligations, or liabilities incident to the ownership and operation of the dam.

1.1.2 Purpose

The purpose of the inspection and evaluation is to identify current physical and operational conditions of the dam and appurtenances; and to determine if emergency measures and/or additional studies, investigations, and analyses are needed, so that corrections can be made in a timely manner by non-federal interests.

1.1.3 Inspection

The findings and recommendations in this report were based on a review of available engineering data pertinent to the design and construction of the Frenchman Reservoir Dam, and a visual inspection of the project.

The State Water Conservation Board provided planning and engineering construction services for the project. Inspection procedures and criteria were those established by the Recommended Guidelines for the Safety Inspection of Dams (Ref. 7).

The inspection was conducted jointly by personnel from Christian, Spring, Sielbach & Associates (CSSA) and Northern Testing Laboratories, Inc., (NTL) subcontractors. Personnel who participated in the field inspection and contributed to this report were:

CSSA- Bob B. Gemmell, Engineer, Team Leader
Alfred Cunningham, Hydraulics/Hydrology (report only)
Les Crawford, Civil Engineer

NTL- Robert Gillespie, Geotechnical Engineer (report only)
Gary Quinn, Geotechnical Engineer
Vijay Bedi, Geologist

Other personnel present and participating in the field inspection include:

MDNRC- Glen McDonald, Dam Safety Engineer

Frenchman Water Users Association-
Bill Brookie
Stan Gartside
Leo Bergtoll

This report has been reviewed by: the State of Montana and their written comments are enclosed in Appendix A. Frenchman Dam Water Users had no response.

1.2 DESCRIPTION OF PROJECT

1.2.1 General

a. Location, Owner, and Purpose

Frenchman Reservoir is supplied by Frenchman Creek, a tributary of the Milk River. The reservoir is located in Sec. 23, T34N, R34E, MPM, in Phillips County, Montana 22 miles north of Saco, Montana by road (Plate 1). The Montana State Water Conservation Board originally planned and constructed the project.

The dam is owned by the MDNRC. The Frenchman Water Users Association operates the reservoir for irrigation purposes.

b. Description of Dam and Appurtenances

Frenchman Reservoir is impounded by a rolled earthfill dam structure. The dam is approximately 44 feet high and about 2,100 feet long. The West Dike is about 8 feet high and 1,000 feet long (Plate 3). The reservoir contains an estimated 21,000 acre-feet at minimum dam crest elevation 2275.5 feet NGVD. The West Dike would discharge approximately 18,000 c.f.s. with reservoir at minimum dam crest. Storage at spillway crest elevation 2264.6 feet NGVD is approximately 7,010 acre-feet. Elevations throughout this report are based on a USGS marker found on the east or left spillway wing wall. Previous reports, including design information are based on a spillway crest elevation of 2245.0 feet which corresponds to elevation 2264.6 feet NGVD used in this report.

Normal reservoir discharges are through the spillway, the outlet works and an irrigation outlet (Photo 1). The spillway is a reinforced concrete chute with an uncontrolled ogee crest at the center of the dam with a 125-foot crest length and a bridge along the crest (Plate 7). The low level outlet works is a 60-inch diameter RCP controlled by two slide gates in a reinforced concrete wet well control tower located near the left abutment of the main dam. A 24-inch diameter concrete pipe irrigation outlet exits from the left side of the wet well and is controlled by it's own slide gate in the wet well (Plate 6).

Reservoir levels are controlled mainly by the spillway and discharges from the outlet works (Photos 8 and 9). The drainage boundary encompasses 2,460 square miles, more than 90% of which is in Canada (Plate 2).

c. Hazard Potential

Based on visual reconnaissance and engineering judgment, a few farm residences could be affected by a sudden breach of the dam. The 1952 dam failure resulted in no known loss of life. On the basis of the recommended inspection guidelines (Ref. 7), Frenchman Reservoir is intermediate in size and the downstream hazard potential is significant (Category 2). The conclusions on probable damage are not supported with a dam breach analysis to determine possible flood heights that would be experienced in the areas downstream that could be affected by a sudden failure. More detailed hydrologic and hydraulic routing studies are needed to more accurately determine the downstream hazard potential.

1.2.2 Regional Geology - Frenchman Creek Dam

The dam and the watershed area are underlain by sedimentary deposits of Cretaceous Age. The area is characterizied by a wide valley surrounded by gently rolling plains. Evidences of valley fill and glacial drift of Pleistocene Age are common in the region.

The Cretaceous Age was characterized by frequent transgressions and regressions of the large Continental Sea, possibly related to the beginning of the Laramide Orogeny (during the Late Cretaceous time). Broad regional uplift in Central Montana is believed to have been the cause of the final withdrawal of the sea.

The normal strata of late Cretaceous Age in the plains of Montana are divided into three major divisions: 1) The Colorado Group of formations, developed during the first great wide spread advance of the sea; 2) the Montana Group, about 1500 feet thick, developed during the advances and recessions of the sea; and 3) the Hell Creek Formation, about 700 feet thick, a landlaid series of sediments developed after the final and complete retreat of the sea (Ref. 5). During the Tertiary, these units were faulted and broadly folded, producing the structure seen in the area today.

The Montana Group underlies the site and surrounding area and consists of the Upper Cretaceous Bearpaw, Judith River, and Claggett Formations (Ref. 3, 4, and 6).

The Bearpaw Formation is composed essentially of a dark gray, marine shale containing numerous concretionary zones and occasional beds of impure bentonite. A few sandstone beds have been observed but none are known to be continuous.

Beneath the Bearpaw is the Judith River Formation, consisting of approximately 500 feet of grayish-white sandstone interbedded with siltstone and shale and occasional thin carbonaceous seams.

The Claggett Formation underlies the Judith River Formation. It is about 700 feet thick, greatly resembles the Bearpaw Shale, and consists chiefly of dark gray marine shale with iron-stained concretions.

1.2.3 Seismicity

The site lies in Seismic Zone 1, a zone of generally minor seismic risk per the Recommended Guidelines (Ref. 7). A seismic coefficient of 0.025 is appropriate for the site.

Preliminary seismic mapping by Algermissen and Perkins indicates there is a 90 percent probability that the horizontal acceleration in rock will not exceed 0.04 in a given 50-year period for the site (Ref. 13).

1.2.4 Site Geology

Frenchman Creek Dam is located in a north-south trending broad, open valley of pre-glacial origin (Photo 2). Following continental glaciation, glacio-fluvial downcutting through glacial moraine, outwash plain deposits, and shale of the Upper Cretaceous Montana Group carved the present creek channel.

A subsurface investigation consisting of seven test holes was conducted prior to the original dam design in 1950; seven drill holes were made subsequently by Simpson Well Drilling after the emergency spillway failure in April, 1952. The borings and test pit logs from the subsurface investigation, along with a visual examination of the area, were used to prepare the site description and the subsurface profile shown on Plate 5.

The glacial and alluvial soils extend to depths ranging from approximately 15 feet to probably greater than 70 feet at the embankment abutments; depths of these glacio-fluvial soils originally were about 30 feet in the main stream channel. Underlying these deposits is shale bedrock of the Montana Group. The bedrock surface rises to the east under the left abutment. Both abutments, however, rest on and are tied to the glacio-fluvial deposits. The dam section of the embankment at the spillway is tied to shale bedrock across the channel floor, while the dam-dike contacts at this location are in glacio-fluvial deposits.

The spillway rests on that portion of the embankment with a cutoff trench to the shale bedrock. The stilling basin apparently has a concrete cutoff wall to the shale. The low-level outlet conduit is founded in the shale bedrock.

1.2.5 Design and Construction History

The Montana State Water Conservation Board (MSWCB) was responsible for both design and construction supervision of the Frenchman Creek Dam. Actual construction was performed during 1950-1951. This original structure had a spillway with only 4 bays for an effective length of 95.5 feet.

At about 5:45 p.m. on April 15, 1952 the Frenchman Creek Dam failed. A Corps of Engineer's report was made in November, 1952, based on eyewitness reports. It concurred with MSWCB engineer Paul K. William's report which is summarized here. The spring snow melt had generated unprecedented high stream flows causing a very rapid first filling of the reservoir. By the morning of April 15, water was spilling over the West Dike (Photo 11). At noon on the 15th a one-foot wide stream was discovered piping out of the dam embankment just east of the spillway at an elevation equal to the spillway crest. The piping washed out the embankment as it grew backwards to the spillway's east wall and then up the embankment (Photo 13). The dam breached late that afternoon and flood waters quickly eroded the earth foundation under the spillway causing it to collapse. No reports of loss of life nor estimates of property damage were available for the writing of this report.

The project was reconstructed in 1952-1953 with a larger spillway and revisions to the seepage cutoff. The project has not experienced stream flows of the 1952 magnitude since it was reconstructed.

CHAPTER 2
INSPECTION AND RECORDS EVALUATION

2.1 HYDRAULICS AND STRUCTURES

2.1.1 West Dike

The right or west end of the earthfilled embankment is approximately 3.5 to 4 feet lower than the main dam crest and for the purpose of identification in this report we have called it the West Dike (Plate 3). Although the design information available did not identify this part of the structure as an emergency spillway it seems reasonable to assume it's lower height was to provide some measure of protection against overtopping for the main dam embankment. Photographs taken during the April, 1952 flood show water flowing over the West Dike crest and possibly protecting the main embankment from overtopping (Photo 11). During that flood the main embankment next to the spillway failed due to piping while the West Dike received no significant damage. Therefore, the West Dike was assumed to be an active element in the routing of the PMF in this report. For purposes of a conservative analysis, it was also assumed that it would withstand overtopping of this routing. It should be noted that the West Dike does not have any protection from sustained flows and would probably begin to erode shortly after being overtopped. Dike failure would contribute to additional flooding, however, potential for loss of life is considered minimal. Effects on any increased spillway capacity by dike erosion on flood routing is beyond the scope of this study.

The discharge capacity of the West Dike was approximated by using the SCS standard drawing number ES-124, sheet 1, contained in SCS Technical Release Number 2 (Ref. 11). The 1,000-foot long, 20-foot wide crest is approximately level. Dike side slopes which serve as the approach and exit gradients are 4 horizontal on 1 vertical and 2 horizontal on 1 vertical, respectively. Photographs taken of the West Dike during the 1952 flood show the control section to be at the downstream shoulder of the dike crest for significant flow depths. A Mannings "n" of 0.040 was used for inlet approach and dike crest flow retardance, with critical depth occuring at the downstream shoulder of the dike crest. The West Dike discharge capacity with the reservoir at dam crest elevation 2275.5 feet NGVD was calculated to be 18,000 c.f.s.

2.1.2 Spillway

The concrete chute spillway is located at the highest part of the embankment dam and near the center of the dam-dike's length. The spillway has a 125 foot long uncontrolled ogee crest at elevation 2264.6 feet NGVD (Plate 7). The bridge across the spillway crest is supported by four 18-inch wide concrete piers making the effective crest length 119 feet. There is about 8 feet of clearance under the wooden bridge and about 10.9 feet between spillway crest and minimum dam crest (Photo 9). Reinforced concrete sidewalls on the exit channel vary from 10 feet high at the crest to 6 feet on the .04 (bottom gradient) sloped chute to 15 feet at the stilling basin. The concrete spillway lining is reportedly underlain with a gravel base course. An underdrain network of vitrified clay pipes was planned to collect and remove any seepage or infiltrated waters from the upper reaches of the spillway, while weep holes were provided for this

purpose in the lower portions. The stilling basin is a reinforced concrete section cast monolithically with the spillway slab.

The spillway is in generally good condition. The concrete chute floor sections have undergone minor differential movements of less than ½ inch. Slab joints have been sealed with a bituminous sealant. However, some loss of this sealant along with additional minor spalling has occurred. Some spalling on the longitudinal slab joint along the easterly retaining wall has also occurred probably due to minor retaining wall movements (Photo 10). These movements are evident at the vertical wall joints and reflected at the retaining wall toe-spillway slab junction. Spillway piers appear to be in satisfactory condition. The stilling basin could not be observed at the time of inspection due to ponding (Photo 6). Energy dissipation is obtained by creation of a hydraulic jump at or near the end sill of the stilling basin. The channel bottom downstream from the stilling basin appears to be stable. Some lateral erosion has taken place near the wingwalls at the stilling basin outlet.

The spillway discharge capacity was computed using accepted methods from Ref. 11, appropriate to an ogee crest with allowance for the constrictions caused by the 4 bridge piers and the sidewalls. The discharge coefficient "C" varied from 3.1 to 4.3. The spillway discharge capacity with the reservoir at minimum dam crest elevation 2275.5 feet NGVD was found to be 17,500 c.f.s. The discharge capacity at minimum dike crest elevation 2272.0 feet NGVD was found to be 9,500 c.f.s.

2.1.3 Outlet Works and Irrigation Outlet

The outlet works is located approximately 200 feet east of the spillway (Plate 6 and Photo 7). It consists of a 60-inch-diameter reinforced concrete pipe (RCP) inlet and outlet; a reinforced concrete inlet structure with a trash rack; a reinforced concrete gate control tower; a reinforced concrete outlet stilling basin; and a 24 inch diameter RCP irrigation outlet. Both the outlet works and the irrigation outlet are controlled by slide gates in the gate control tower. The guardian gate and operating gate for the 60-inch-diameter outlet pipe are operated by an electric motor which in turn is powered by a small portable gasoline powered generator when large openings or closures are required. For small adjustments the gates are operated manually.

Reservoir levels can be regulated by the slide gate on the outlet works. The upstream guardian gate was closed during the inspection to allow access to the control gate and outlet conduit. The gate, the conduit, and the stilling basin were in good condition with only minor signs of cavitation in the concrete immediately downstream of the gate. The conduit upstream of the guardian gate, the stilling basin floor, and the irrigation outlet's gate and conduit could not be inspected.

The discharge capacity of the outlet works and the irrigation outlet were calculated using a Mannings "n" of 0.014 for full pipe flow conditions. It was assumed that both 60-inch gates on the outlet works would be open and the irrigation outlet gate would be closed during the routing of the PMF. The discharge capacity of the outlet works with the reservoir at minimum dam crest elevation 2275.5 feet NGVD was found to be 505 c.f.s. A discharge rating curve combining the low level outlet works, the spillway and the West Dike is shown on Plate 8.

The irrigation outlet exits from the left side of the control tower/wetwell structure through an 80 foot long, 24-inch diameter RCP and discharges into an open irrigation channel on the left abutment (Plate 6).

2.1.4 Freeboard

The dam overtops during the recommended spillway design flood (see Paragraph 2.2.4), so it has no freeboard. The reservoir was at spillway crest elevation 2264.6 feet NGVD at the time of inspection with a very small flow over the spillway crest. The crest of the West Dike is approximately 7 feet above spillway crest. Spillway flows occur annually.

The maximum fetch for wind generated waves that would affect the main dam is estimated to be 6,000 feet, and wave runup on the embankment is estimated to be less than 4 feet. There is little likelihood of overtopping the embankment by wind generated waves under normal operating conditions.

2.2 HYDROLOGY

2.2.1 Physiography and Climatology

The Frenchman Dam Reservoir is located at latitude 48° 45' and at longitude 107° 10' near the town of Saco, Montana (Plates 1 and 2). The project impounds water from Frenchman Creek for the purpose of meeting downstream irrigation demands. The site is located in what is commonly known as the northern Great Plains of Montana which is characterized by flat, treeless expanses, and large gently rolling hills.

The climate of this region of Montana is commonly considered Continental and therefore typical of the interior of a large land area. Weather in this region is highly variable with rapid changes brought on by the invasion of large air masses from the Gulf of Mexico, the South and Southwest, the North Pacific, and Polar Regions. Montana is in the westerly wind belt throughout the year with the result that much of its weather comes from the Gulf of Alaska. Temperature variation is extreme with highs at the Frenchman Reservoir site ranging in the upper nineties and winter lows down to about minus thirty (Ref. 1). The average "freeze free" season at the Frenchman Reservoir site is about 125 days ranging from mid-May to mid-September. Average annual precipitation is between 10 and 12 inches with heavy amounts occurring in the form of summer thunderstorms. Annual average lake evaporation at this site is about 40 inches. A discharge measurement taken 2 miles above the mouth of Frenchman Creek recorded peak flows of 9,700 c.f.s. during the April 1952 flood. A stream gauge located at the International Boundary recorded peak flow (other than 1952) of 5,400 c.f.s. in 1925. The peak flow in 1952 was estimated at 22,700 c.f.s., according to the USGS Water Data Report MT-75-1.

2.2.2 Reservoir Storage and Spillway Discharge

The Frenchman Reservoir has a storage of 7,010 acre-feet at the spillway crest elevation 2264.6 feet NGVD and 21,000 acre-feet at minimum dam crest elevation 2275.5 feet NGVD, thereby providing approximately 14,000 acre-feet of surcharge storage. The combined spillway capacity (i.e. the outlet works, the spillway and the west dike overflow) is about 36,000 c.f.s. with the reservoir at dam crest elevation 2275.5 feet NGVD.

2.2.3 Estimated Probable Maximum Flood

The probable maximum flood (PMF) is the flood expected from the most severe combination of meteorologic and hydrologic conditions that are reasonably possible in the region.

The 840 square mile study PMF for Frenchman Reservoir was developed using the HEC-1 Flood Hydrograph Dam Safety Computer Program (Ref. 8). Primary program input consisted of the 72-hour probable maximum precipitation (PMP) which was obtained for the study site from Ref. 2. The 24-hour 10-sq. mile PMP value was determined from Ref. 2 to be 22 inches. PMP values for duration of 1, 2, 3, 4, 5, 6, 12, 24, 48 and 72-hours were also determined from Ref. 2 and used to plot a depth-duration curve. These values involved an area adjustment factor based on the 2,460 square mile drainage area. This curve was used to find one-hour incremental PMP values which were subsequently arranged in their critical sequence according to Ref. 12. Total precipitation for the 72-hour period was found to be 13.20 inches and the maximum hourly value was 5.31 inches.

Val Marie Reservoir, 126 miles upstream, is the first project above Frenchman Reservoir (Plate 2). In order to simplify the development of the study PMF, floodwaters generated from that part of the drainage basin upstream from Val Marie Reservoir were assumed to be entirely controlled by four upstream reservoirs and thus did not contribute to flooding at Frenchman. This assumption reduces the effective drainage area from 2,460 square miles to 840 square miles used for this study and is therefore not representative of the PMF that could be experienced by the project. For purposes of this Phase I investigation, it was assumed that if Frenchman was overtopped by these conditions it would obviously be overtopped if upstream reservoirs did not control their floodwaters. Accordingly the time of concentration for Frenchman was estimated as the travel time along the 126 mile channel reach from Val Marie Reservoir to Frenchman Reservoir. (Based on a 5 ft/sec. average stream velocity.) This assumption, which we regarded as more realistic than using the Kirpich equation, resulted in an estimated time of concentration of 37 hours. This time of concentration, together with a reduced drainage area of 840 square miles, was used as the basis for applying the SCS unit hydrograph procedure to develop flood hydrographs for this inspection.

Combination of the critical PMP sequence with the SCS unit hydrograph resulted in the study PMF inflow hydrograph to Frenchman Reservoir. An infiltration rate of .15 inches/hour was assumed for the entire drainage area based on information from Ref. 9.

Based on an assumption of storm activity prior to the occurence of the PMP it was assumed that base flow of 100 c.f.s. prevailed during and after the study PMF.

2.2.4 Flood Routing

Routing of the estimated study PMF hydrograph through Frenchman Reservoir was accomplished by means of computer program HEC-1 (Ref. 8). Initial reservoir surface elevation was assumed to be at spillway crest elevation 2264.6 feet NGVD at the onset of the study PMF while initial inflow was assumed to be 100 c.f.s. Infiltration was taken to be .15

in/hr. for the entire storm and the modified puls method was used for reservoir routing.

Routing studies showed that Frenchman main dam was just overtopped by a flood which was equal to 28% of the study PMF hydrograph ordinates. With the full study PMF, overtopping began 49 hours after the onset of the PMP and lasted for 32 hours. Frenchman Reservoir was found to control only 6 percent of the study PMF inflow volume prior to overtopping.

2.3 GEOTECHNICAL EVALUATION

The Frenchman Creek Dam is an irrigation storage facility that closes two natural channels in the Frenchman Creek Valley. The dam, designed by the State Water Conservation Board, was breached in the spring of 1952, shortly after completion, during a period of unusually high runoff. Following some design modifications by SWCB, the dam was reconstructed in 1952-1953.

The cause of breaching, as determined from post-failure review by the COE and SWCB, was attributed to piping and the resulting scour erosion of embankment materials along the left or east wall of the concrete spillway. The review did not indicate any serious drainage problems within the main dam embankments, but did note a continuous gravel layer in the creek bed foundation materials. This gravel layer did not appear to contribute to the 1952 failure, however its behavior under sustained high pool conditions does not appear to have been investigated. Cutoff dimensions and depth were accordingly revised in reconstruction to reduce future potential for underflow. There does not appear to be any filter or drainage provisions within the embankment.

2.3.1 Dam-Dike Embankment

The construction drawings identify 2 dams and 3 interconnecting dikes. For simplicity, the dam and dike embankments are referred to as the dam in this report. The portion of the right or western most dike that has a 3.5 to 4 foot lower crest is referred to as the West Dike.

The dam-dike embankment close natural drainage courses in the Frenchman Creek Valley. The embankment extends for a length of 3,100 feet across the valley. About 1,000 feet of the West Dike is lowered 3.5 to 4 feet to allow for flood waters to overflow there and protect the main dam embankment from overtopping. A plan view of the dam-dike embankment is shown on Plates 3 and 3A.

Design drawings indicate the dam embankment to be a zoned earthfill comprised of the following zones: upstream riprap facing on a sand-gravel blanket, rolled earth fill core, and compacted earth-gravel-boulder downstream shell (Plate 4). These drawings also indicate a 10 to 20 foot-wide cutoff trench extending from the core into foundation materials; the resulting maximum embankment height above trench bottom is 63 feet. The maximum hydraulic height of the embankment is 44 feet. The plan upstream slope is 1V on 3H, with a 20 foot wide bench located 25.5 feet below the dam crest. A waste berm was planned beyond the upstream toe. The downstream slope is typically 1V on 2H, but flattens between the spillway and outlet conduit. A crest width of 20 feet is shown on the plans.

The dike embankment is also indicated by design drawings to be a zoned earth fill consisting of a sand-gravel upstream shell overlaying an earth fill core (Plate 4). The plan upstream and downstream slopes are 1V on 4H and 1V on 2H, respectively. The dike crest width is shown on the plans to vary from 8 to 20 feet in width. However, a 20 foot wide roadway traversed the length of the dam/dike crest at the time of our inspection. Maximum height of the dike embankment is indicated by the drawings to be on the order of 8 feet.

Specifications for the various zoning materials called only for locally available materials selected for a desired degree of imperviousness as determined by the field engineer. Foundation preparation and compaction specifications appear reasonable for then state-of-the-art practices. With the blended, moisture-conditioned materials placed in the lift thicknesses and compacted as specified, densities obtained would probably be in the range of those attainable under standard Proctor compactive effort.

The recent inspection found the crest of the dam-dike embankment to be well-aligned, with no visible signs of settlement or cracking (Photos 3 and 5). The roadway across the embankment crest is approximately 28 feet in width including shoulders. The roadway, surfaced with a sand-gravel mixture, appears to be generally well-maintained. On the timber deck bridge, crossing the spillway, some deterioration of the asphalt concrete deck surface and the timber guard railing was noticed.

The higher portions on the upstream slopes along the dam-dike embankment were found to agree substantially with plan cross-section. However, wave erosion has resulted in vertical cuts 2 to 5 feet in height along much of the dike section of embankment (Photo 4). The fill soils observed in these wave cut faces varied from clayey sand and gravel to weathered clay-shale. Some wave erosion was also observed in the dam embankment between Stations 16+75 and 20+00 where riprap was incomplete and lacking. Minor wave erosion was noted beneath the riprap protection in some portions of the dam embankment left of the spillway. No longitudinal or transverse cracking was observed. The bench in the upstream slope was submerged and could not be inspected.

The downstream slopes of the dam-dike embankment had slopes typically equal to or slightly flatter than those shown on plan drawings. No cracking or settlement was observed. Materials observed on the slope faces were typically sand-gravel-cobble mixture; the sagebrush vegetation on the slopes is sparse. Runoff erosion has resulted in minor localized sloughing particularly in the area above the outlet conduit. Minor damage due to the animal travel was also noted.

The abutment contacts appeared sound and did not show evidence of any seepage or erosion.

2.3.2 Foundation Conditions, Seepage and Drainage

The dam-dike embankment closes two natural drainage courses. These courses have been cut through valley fill materials, primarily of glaciofluvial origin, and into shale deposits of Upper Cretaceous Age.

The typical geologic cross-section shown on Plate No. 5 was developed using available drill and test hole logs. Weathered shale of the Montana Group comprises the valley floor; the shale surface appears from the logs to deepen with westerly progression across the site. The overburden consists of reworked till, outwash, and some lacustrine materials complexly interbedded by glacio-fluvial and recent deposition processes. Drill logs did not report consistency/relative density of these foundation materials.

The cutoff trench for the dam embankment-spillway section reportedly extends to the shale bedrock between Stations 6+60 and 11+00 and ties into glacio-fluvial valley fill materials at the dam-dike contacts. (The original, pre-failure, cutoff depth across this section apparently did not extend to shale beneath the spillway.) The cutoff trench along the dam embankment from Stations 16+75 to 20+00 is entirely in the glacio-fluvial soils. The dike-valley fill contacts form the embankment abutments. The materials observed were typically fine sandy clays at the ground surface. Reportedly there are no piezometers or other methods of determining internal water levels.

2.3.3 Stability

No records of stability analysis were available for our review and there is insufficient geotechnical data to make such an assessment. However, the 28 year old structure shows no signs of mass instability.

2.4 PROJECT OPERATIONS AND MAINTENANCE

2.4.1 Dam Maintenance Plan

Project maintenance inspections have been made on several occasions by the MDNRC. Records of these inspections were made available for review. Deficiencies reported consist mostly of minor concrete spalling, occasional brush removal, erosion caused by livestock trails and unsafe bridge railing. The reports indicate the water users have made efforts to patch spalling concrete in the spillway joints and have removed most of the brush from the embankment. Maintenance of the gate controls has been performed by the operator as needed as a part of normal operating procedures. There is no published maintenance plan.

The project is visted frequently by water users during the irrigation season. A county road crosses the dam crest and there are a couple of residences on the north west shore. Problems or needed maintenance has usually been observed before it becomes serious.

2.4.2 Reservoir

Pool levels fluctuate with the irrigation season requirements. Normal maximum pool elevation appears to be about 2265 feet NGVD. Minimum normal pool elevation is reported to be about 2255 feet NGVD. Reservoir records were not available for review. There is no formal plan for reservoir operations. Because of the large drainage area, loss of usable storage by water carried sediments deposited in the reservoir appears to be a problem. Sediment bars of recent origin were noted at the stream entrance to the reservoir.

2.4.3 Warning Plan

There is no formal downstream warning plan in case of impending dam distress.

CHAPTER 3
FINDINGS AND RECOMMENDATIONS

3.1 FINDINGS

Visual inspection of the dam, supplemented by analysis of available engineering data for the project in accordance the Recommended Guidelines (Ref. 6) resulted in the following findings:

3.1.1 Size, Hazard Classification and Safety Evaluation

The 44-foot high dam and the 8-foot high dike impound about 21,000 acre-feet of water with the reservoir at minimum dam crest. In accordance with inspection guidelines, the Frenchman Reservoir Project is intermediate in size and based on our visual inspection and judgment, it has a significant (Category 2) downstream hazard potential. Therefore, the guideline's recommended spillway design flood (SDF) for this project is 50 percent of the PMF. Based on the involved risk, we recommend that the project safely handle one-half of the total PMF. Based on reconnaisance level investigations, and routing of the estimated study PMF developed for this study, the project is capable of handling a flood having hydrograph ordinates equal to 28% of the study PMF ordinates without overtopping and causing the dam to fail. The project would handle less than 28 percent of the total PMF from the entire 2,460 square mile drainage basin.

Because the project cannot pass the recommended study SDF without overtopping, Frenchman Dam is not in conformance with the inspection guidelines.

3.1.2 Spillway

The spillway is a reinforced concrete chute with an uncontrolled ogee crest located at the south end of the reservoir. The 119-foot effective length on the crest shows no signs of deterioration. Some concrete spalling was observed near joints in the exit chute. There were no significant irregularities and the spillway appeared to generally be in good condition. Periodic repairs of cracks and spalls have been performed as needed by dam maintenance personnel.

3.1.3 Outlet Works

a. Low Level Outlet Works

The low level outlet is a 60-inch diameter RCP with 2 slide gates located in a control tower at the dam crest. The reservoir inlet and trashrack were submerged at the time of inspection and their condition could not be visually determined. The upstream gate was in a closed position at the time of inspection and appeared to be sealing adequately. Minor concrete spalling or cavitation damage was observed downstream of the second gate. Overall, the principal outlet works appeared to be in good condition.

b. Irrigation Outlet Works

The irrigation outlet is a 24-inch diameter conduit which has its inlet and control gate in the control tower/wet well. It discharges into a high level irrigation channel on the left abutment of the main dam. A visual inspection of the conduit was not made.

3.1.4 Reservoir Storage and Discharge Capacity

The reservoir has a surface area of about 800 to 1,000 acres and a storage of 7,010 acre-feet at spillway crest elevation 2264.6 feet NGVD. Approximately 14,000 acre-feet of surcharge storage is available between the spillway crest and minimum dam crest elevation 2275.5 feet NGVD. The discharge capacity of the spillway, with the reservoir at minimum dam crest elevation 2264.5 feet NGVD is approximately 17,600 c.f.s. The low level outlet works has a capacity of approximately 505 c.f.s. with reservoir at minimum dam crest. The West Dike, which acts as an emergency spillway has a discharge capacity of 18,000 c.f.s. with reservoir at minimum dam crest. The reservoir capacity appears to be diminishing by sediment deposits carried in with flood flows and annual "high water" flows. Estimates of annual sediment rates should be made to determine useful life of reservoir storage.

3.1.5 Dam-Dike Embankment

The dam-dike embankment is a zoned earth fill constructed with local glacio-fluvial materials. Foundation materials consist of varying thicknesses of the glacio-fluvial deposits over shale bedrock.

Performance of the embankment has been good with no evidence of misalignment, cracking, or significant settlement. Abutment contacts appear sound and no seepage was observed. Wave erosion has, however, made a vertical cut 2 to 5 feet in height along the unprotected sections of the upstream dam and dike embankment face.

3.1.6 Stability

The embankment breaching in the spring of 1952 was due to flood stage waters piping and scouring material from behind the left abutment wall of the spillway. There are presently no seepage or performance conditions that indicate instability under present operating conditions. A quantitative assessment of embankent stability cannot, however, be made without additional geotechnical data.

3.1.7 Operations and Maintenance

Normal pool elevations are maintained at or near the spillway crest by normal stream flows and outflow for irrigation. No formal operations plan for the reservoir exists. Maintenance is performed by the Water Users Association as necessary. There is no formal warning plan for use in the event of impending dam failure.

3.2 RECOMMENDATIONS

Due to available surcharge storage the present project provides a degree of flood protection to the downstream area. The intent of report recommendations is to maintain or improve project safety, if feasible, without decreasing the existing flood protection.

1. Immediately develop, implement and periodically test an emergency warning plan for use in event of impending dam distress.

2. Repair the wave erosion damage on upstream dike and unprotected dam embankment slopes, and provide riprap slope protection.

3. Inspect the 24-inch-diameter irrigation conduit and 60-inch-diameter outlet in in its entirety. Repair if required.

4. Repair concrete spalling in the outlet works and in the spillway as needed.

5. Perform more detailed hydrologic and hydraulic routing studies to better define the recommended spillway design flood and downstream hazard potential. Modify the project as the studies indicate. These studies should take into account the operation of upstream reservoirs and include updated reservoir storage information and estimates of usable storage depletion by sediment deposits. The studies should also consider effects of emergency spillway erosion/failure on downstream flooding and flood routing capabilities of the project.

6. Develop and implement a formal operations and maintenance plan for the project. Perform annual maintenance inspections, with particular attention to repair and maintenance of concrete structures. Conduct inspections of Frenchman Dam and Dike at least every 5 years by qualified engineers experienced in earth dam design, construction, operation, and maintenance.

7. Inspect the spillway stilling basin for damage and repairs required.

8. Install piezometers and monitor to accurately determine the pore pressure distribution within the embankment. Have a qualified geotechincal engineer perform and place on file seepage and stability analysis.

FRENCHMAN DAM
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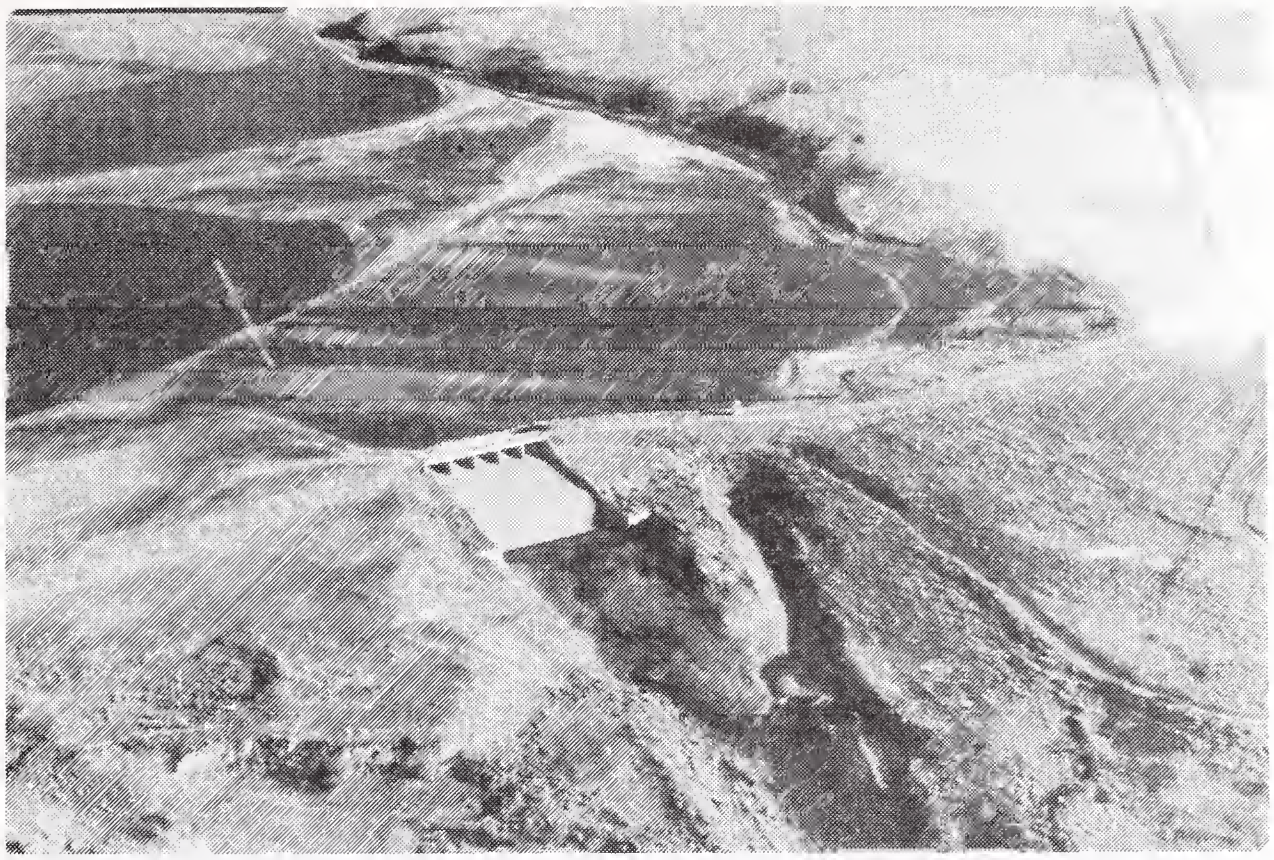


PHOTO 1
Aerial View of Frenchman Dam 11/80

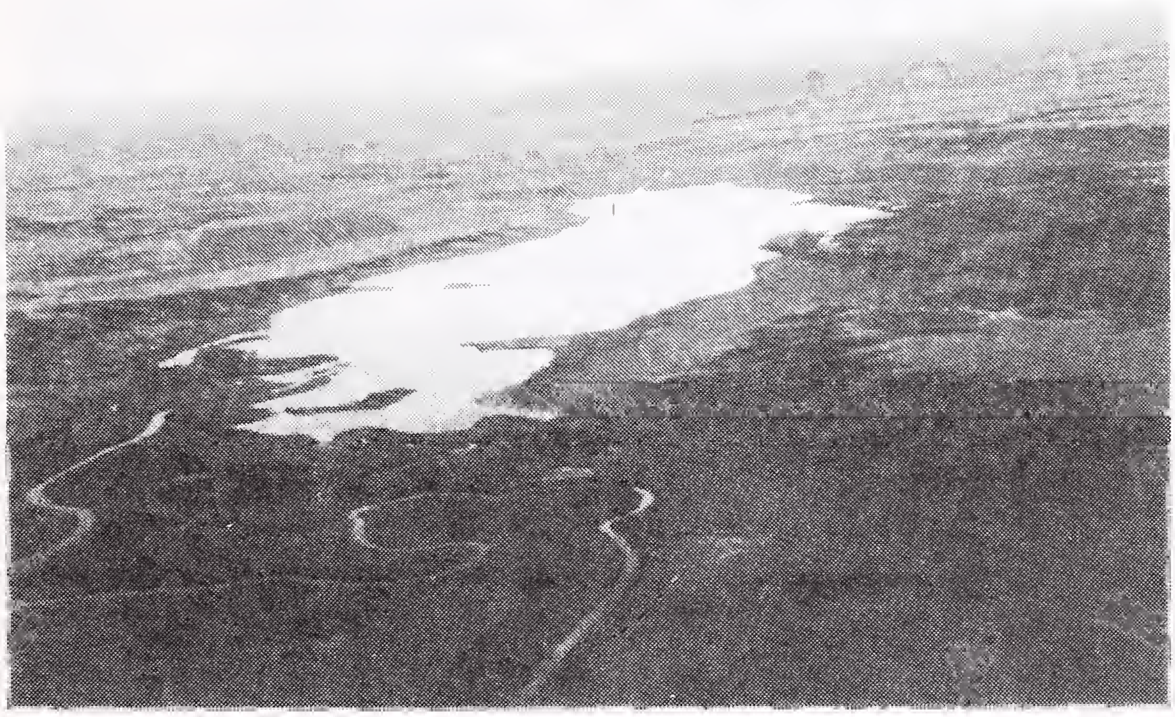


PHOTO 2
Frenchman Reservoir
Note: Sedimentation at head.

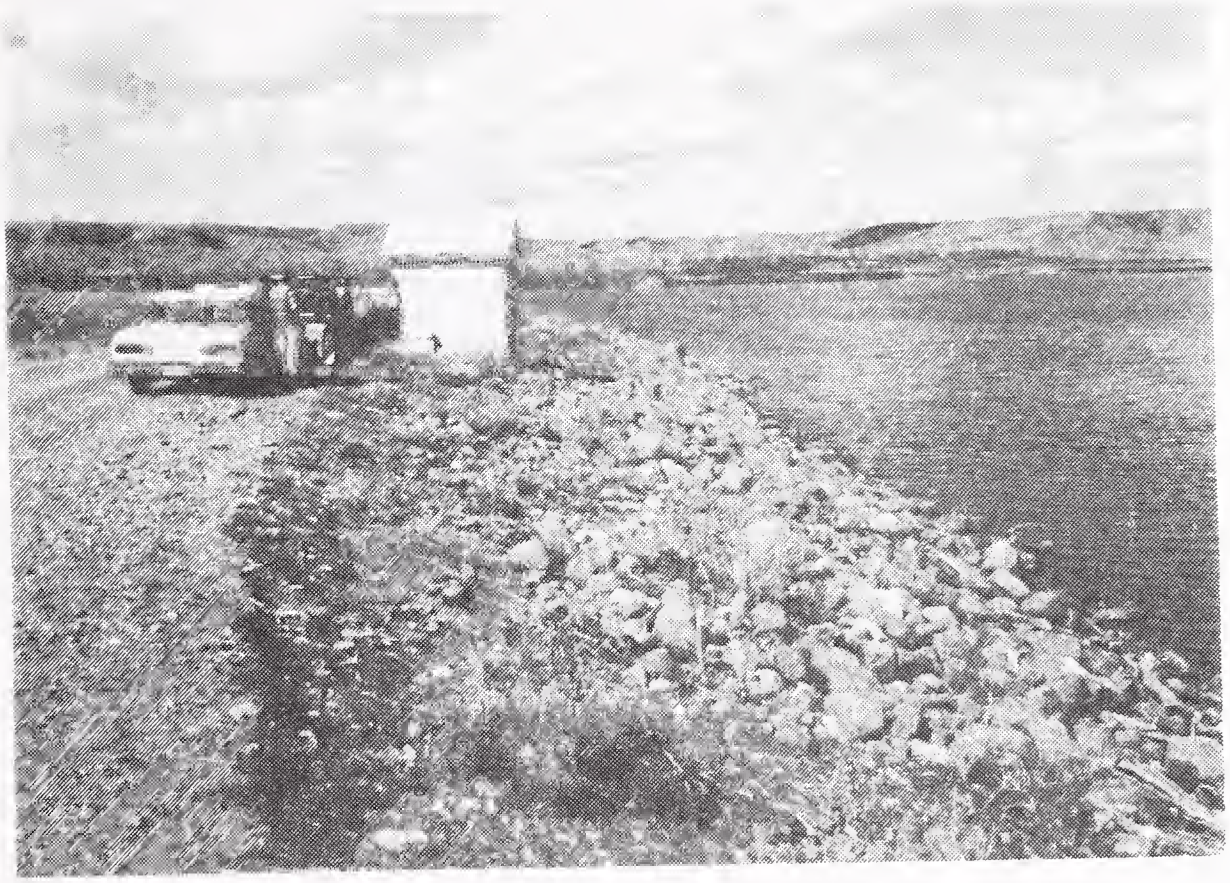


PHOTO 3

Upstream Face at Control Tower

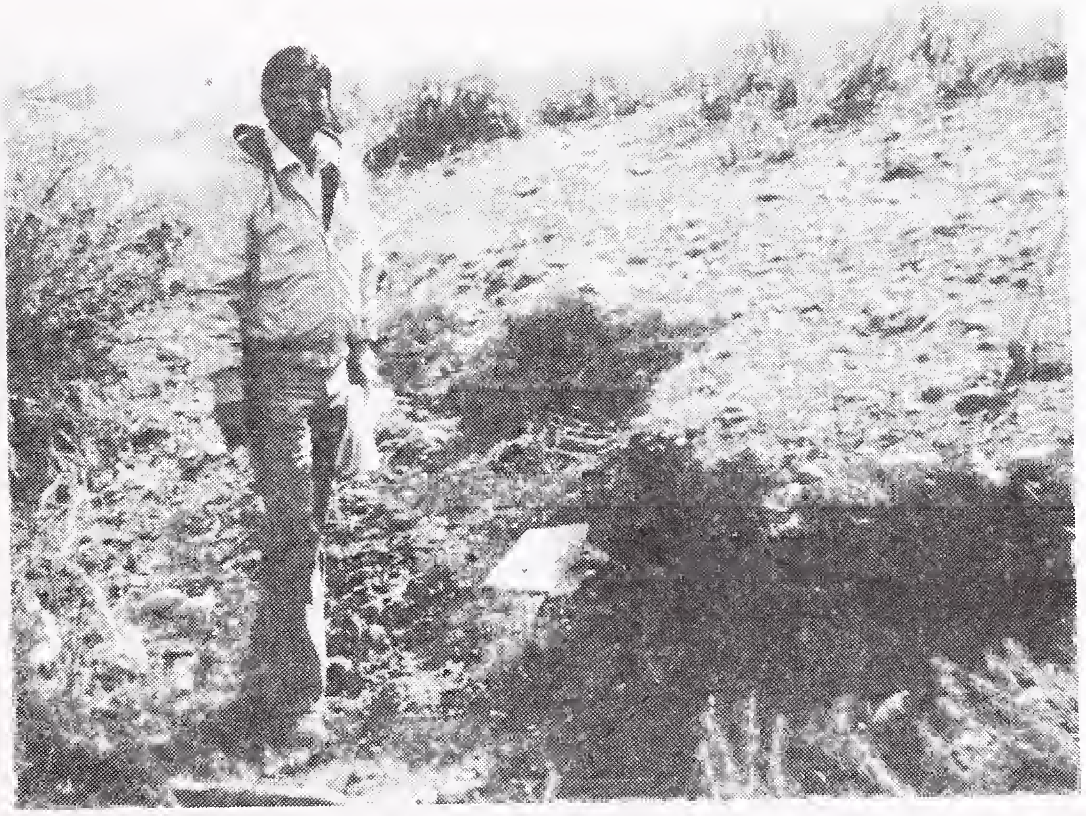


PHOTO 4

Erosion Bench on Upstream Face

West of Spillway

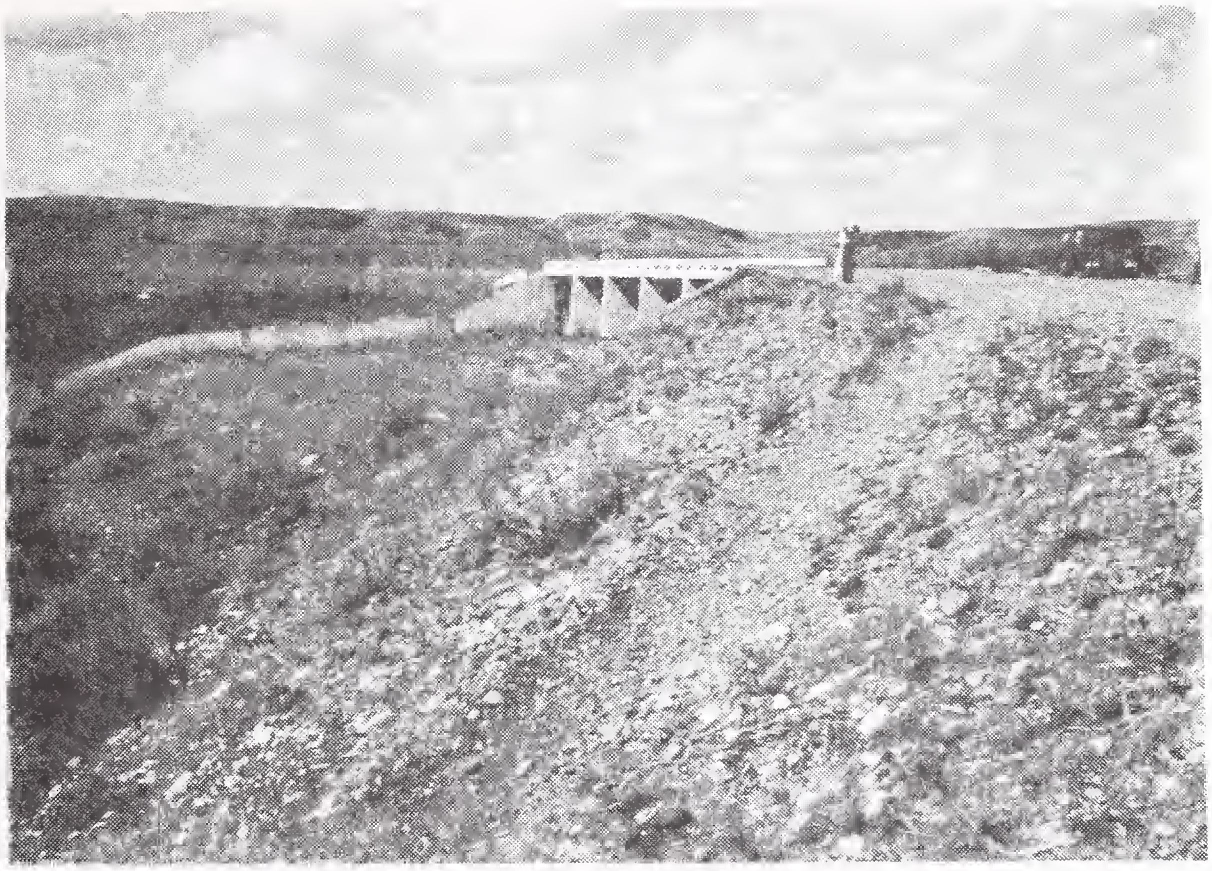


PHOTO 5

Downstream Face

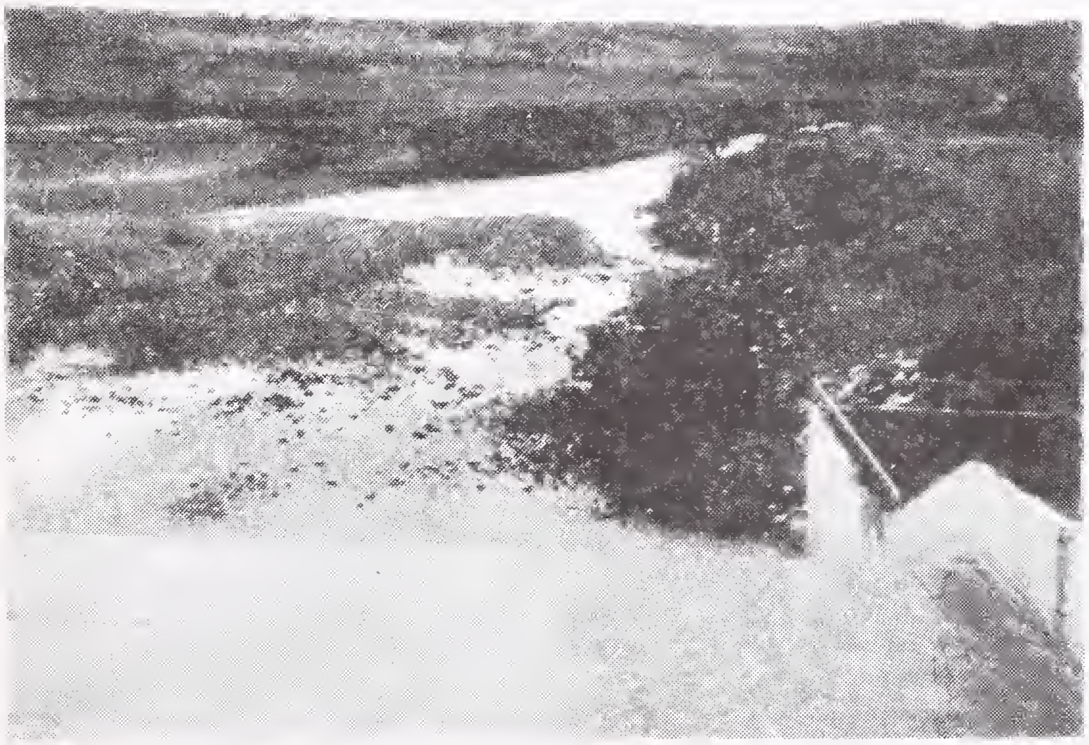


PHOTO 6

Channel Downstream of Spillway

PHOTO 7

Irrigation Outlet

PHOTO 8

Outlet Works

Note: Water line caused by negative channel gradient

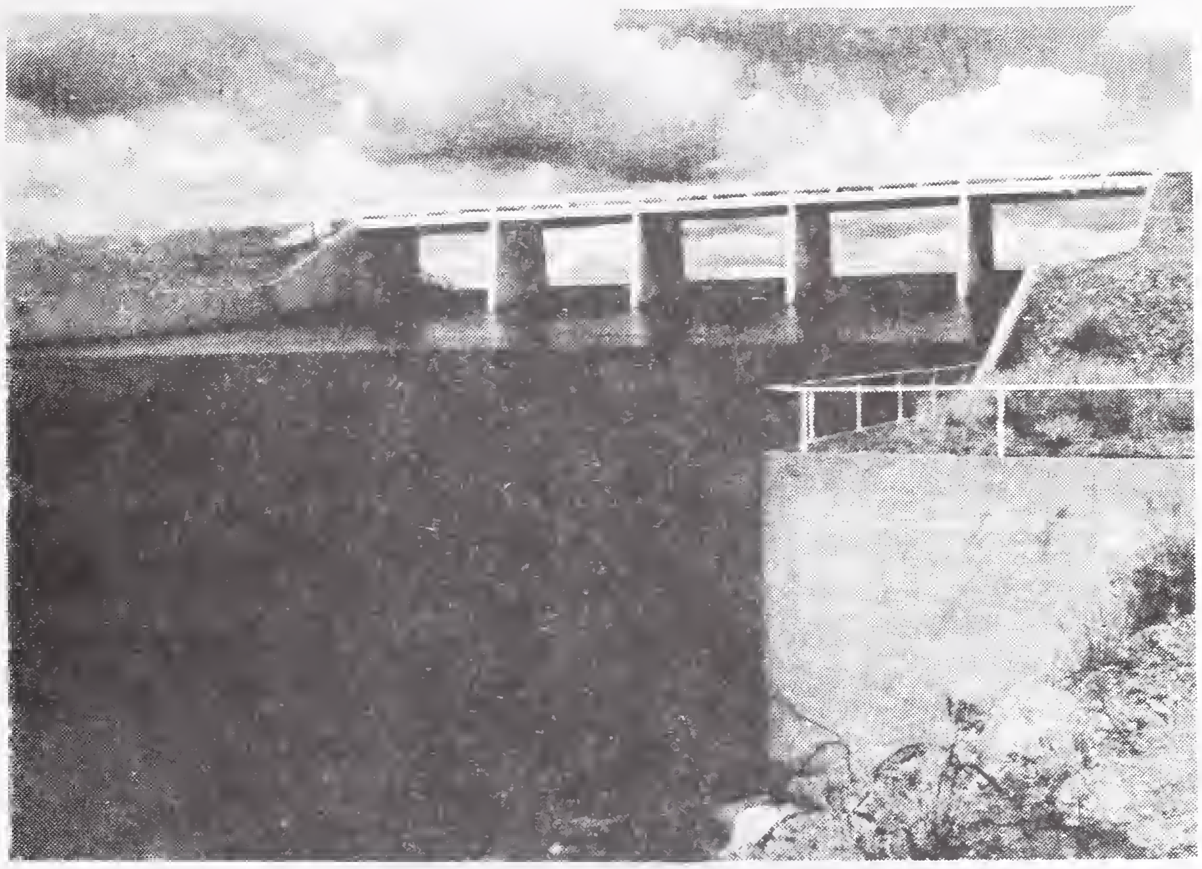


PHOTO 9

Spillway Channel & Bridge

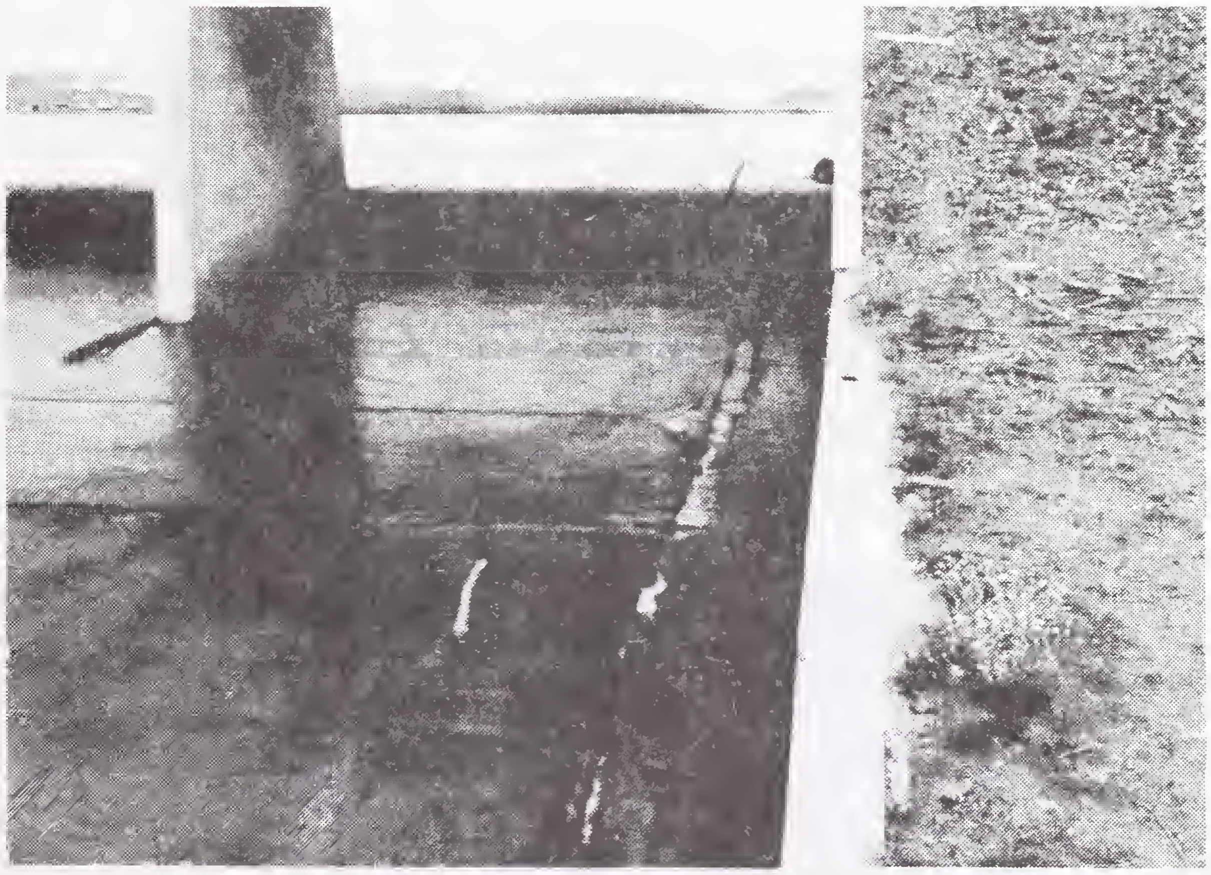


PHOTO 10

Spillway Channel & Crest

Note: Concrete Spalling at Joint

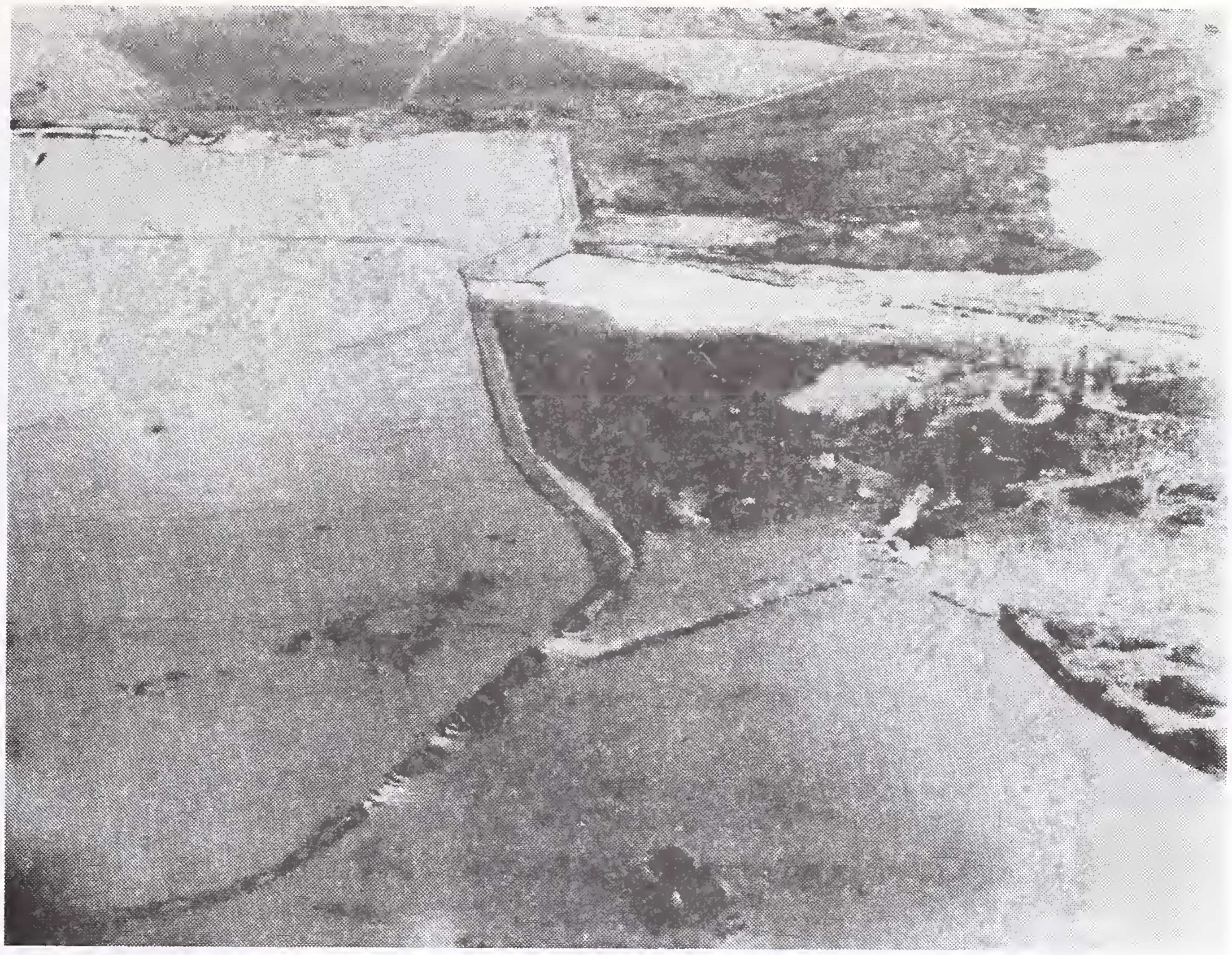


PHOTO 11

Frenchman Dam Mid-day April 15, 1952

Note: Flow across West Dike at bottom of photo

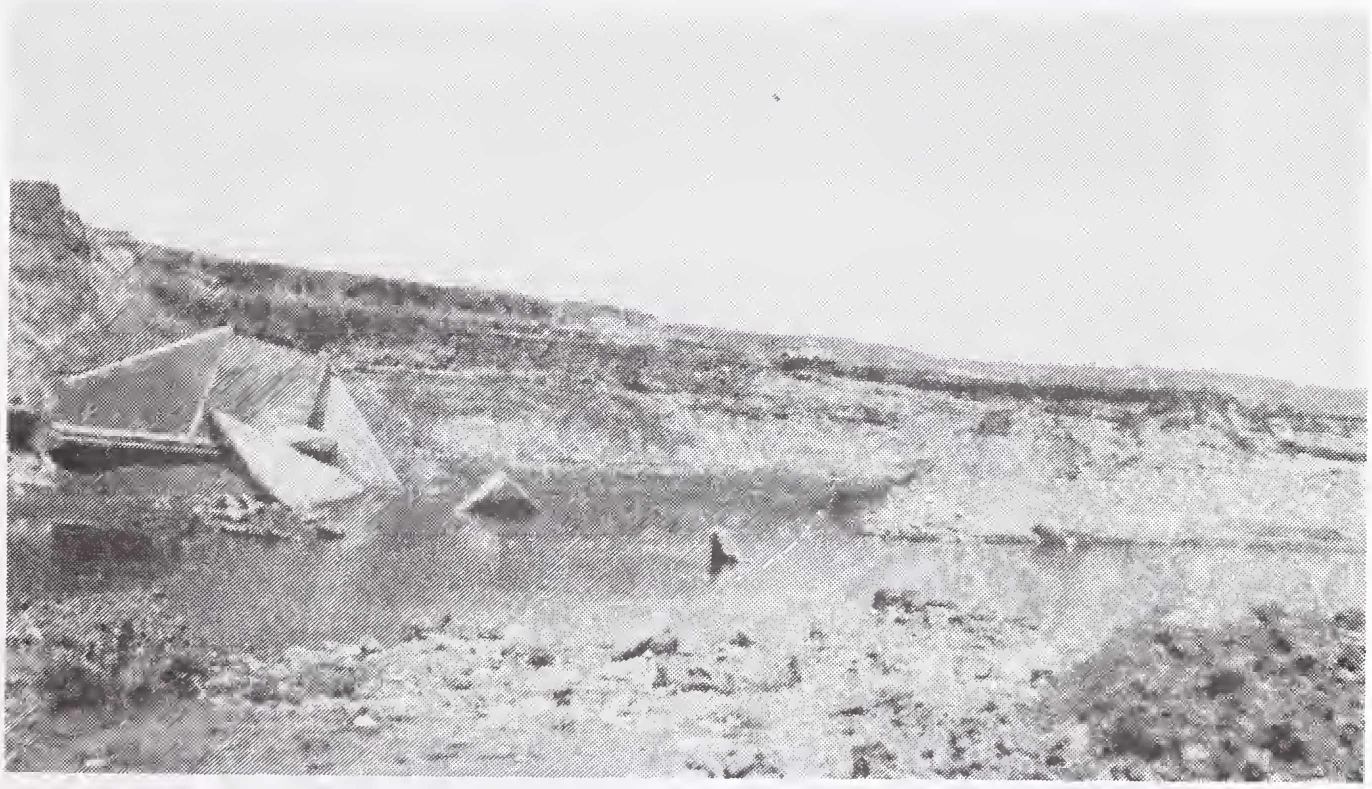


PHOTO 12

Frenchman Dam Spillway April 16, 1952

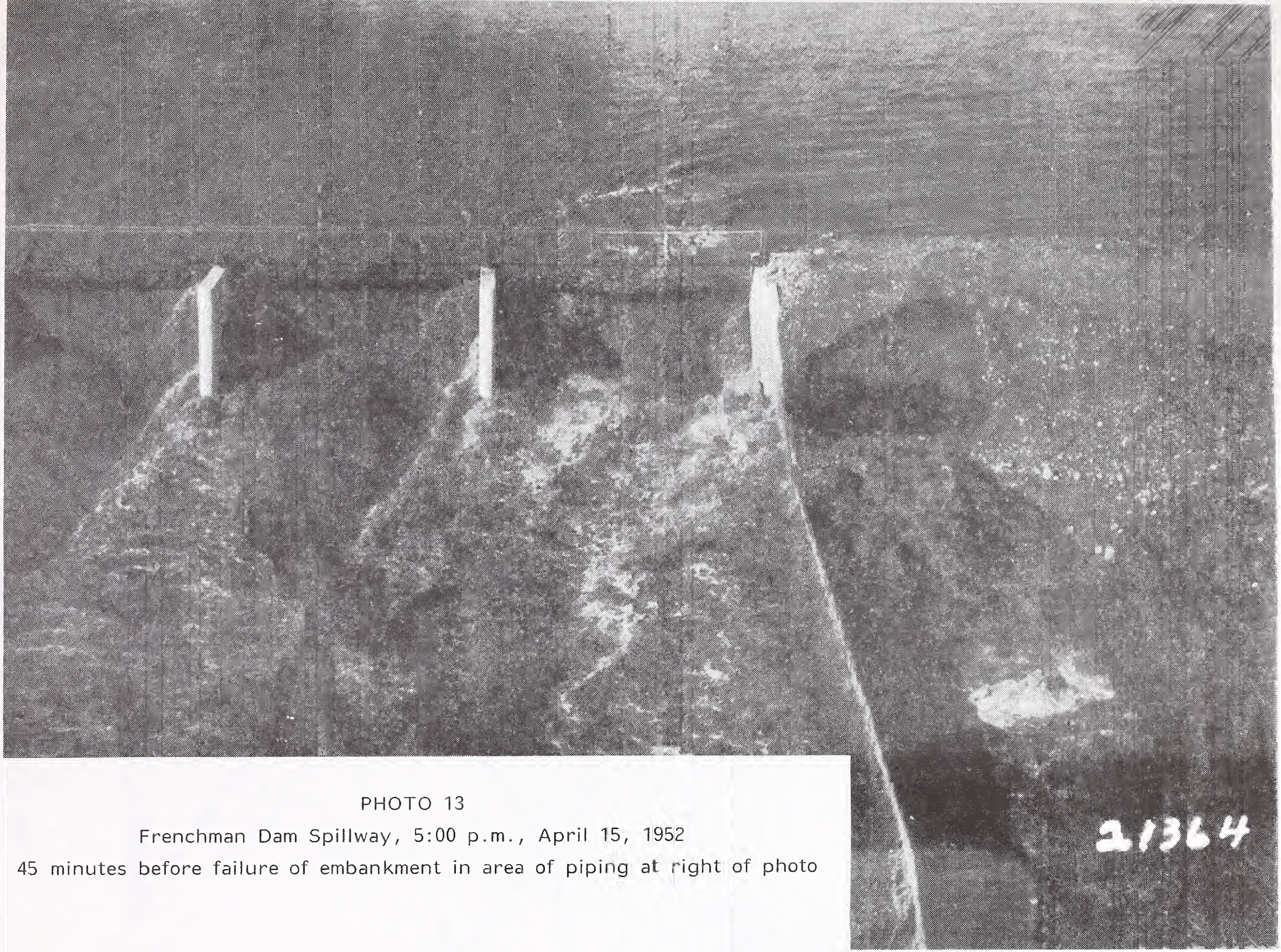


PHOTO 13

Frenchman Dam Spillway, 5:00 p.m., April 15, 1952

45 minutes before failure of embankment in area of piping at right of photo

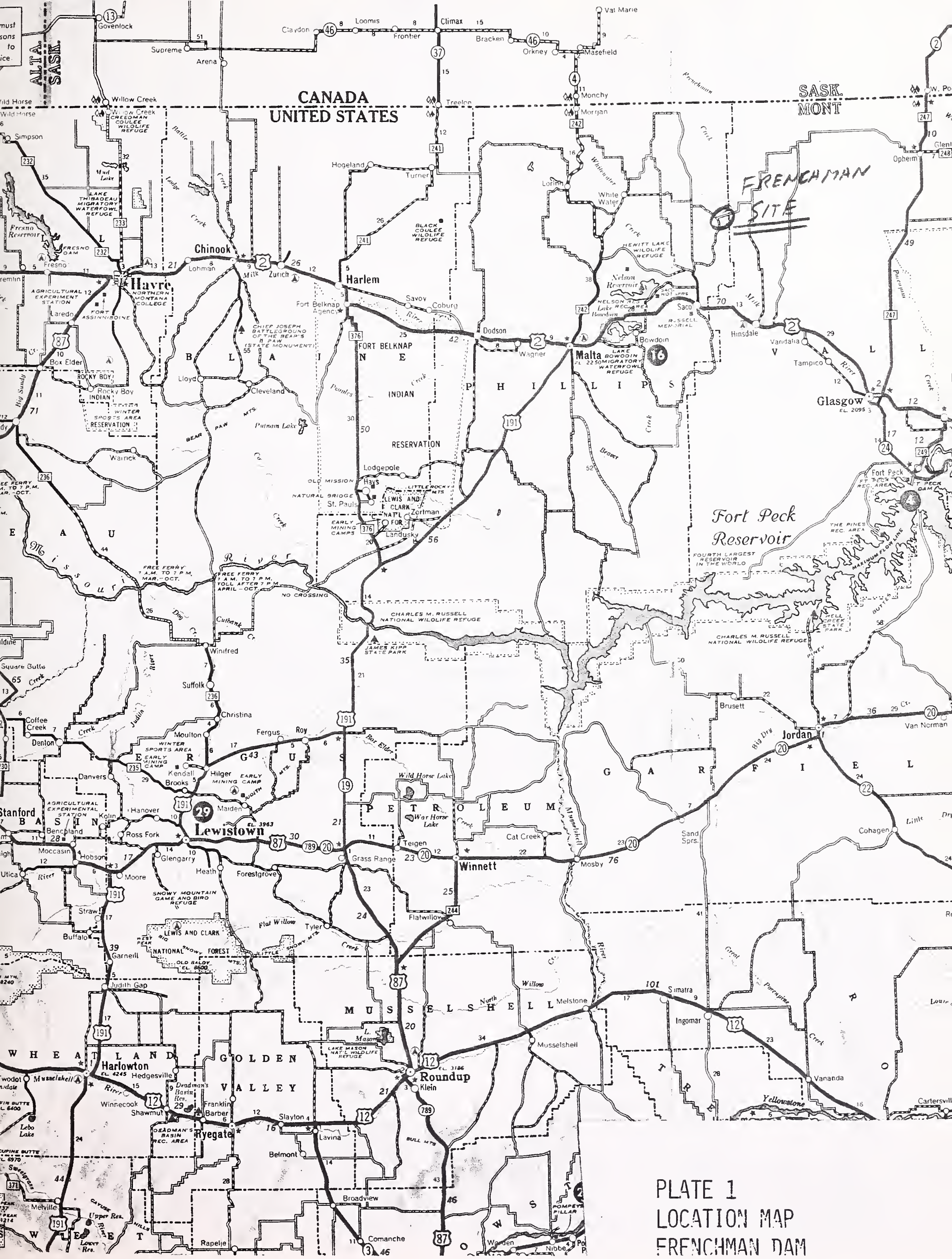


PLATE 1
LOCATION MAP
FRENCHMAN DAM

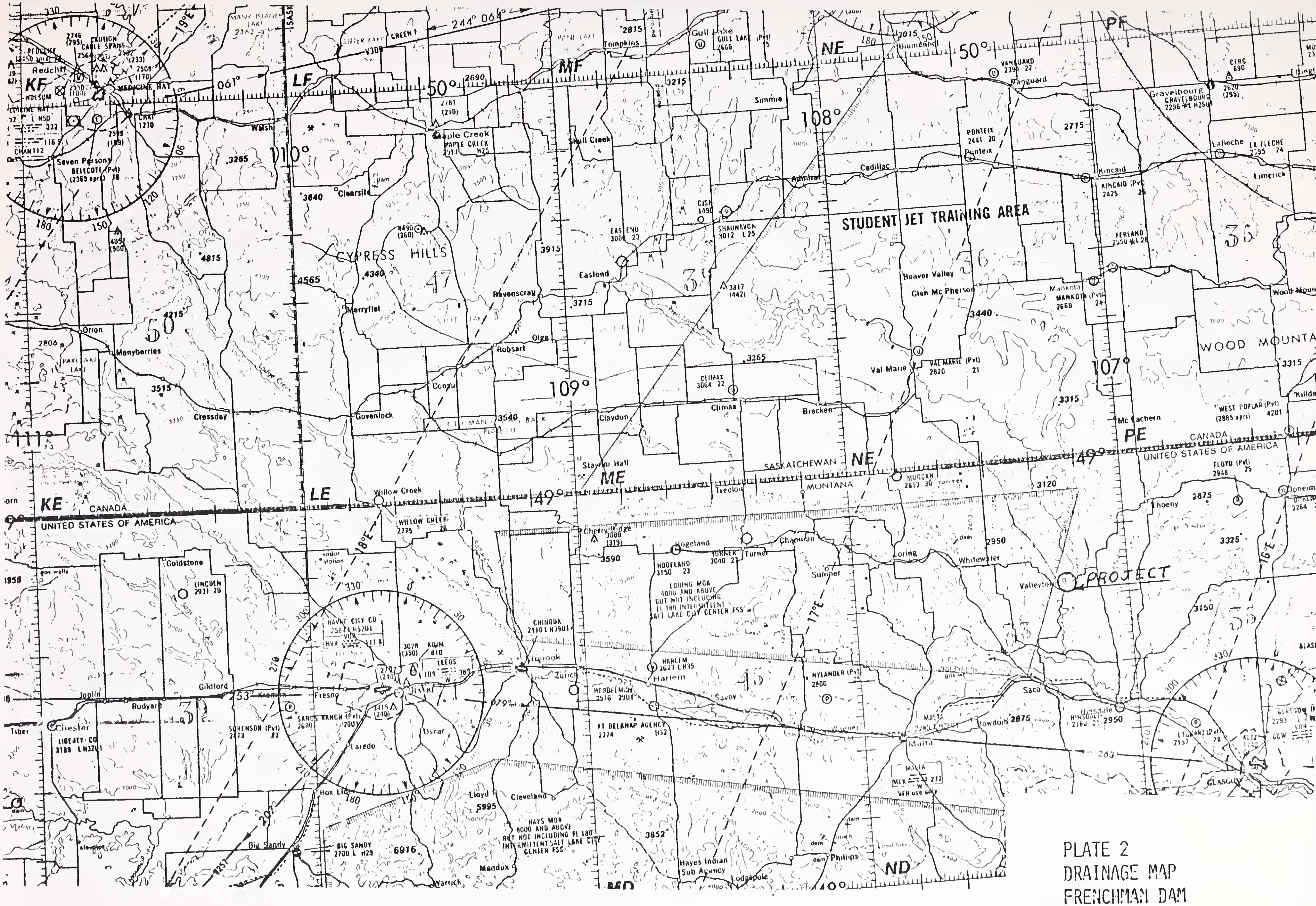
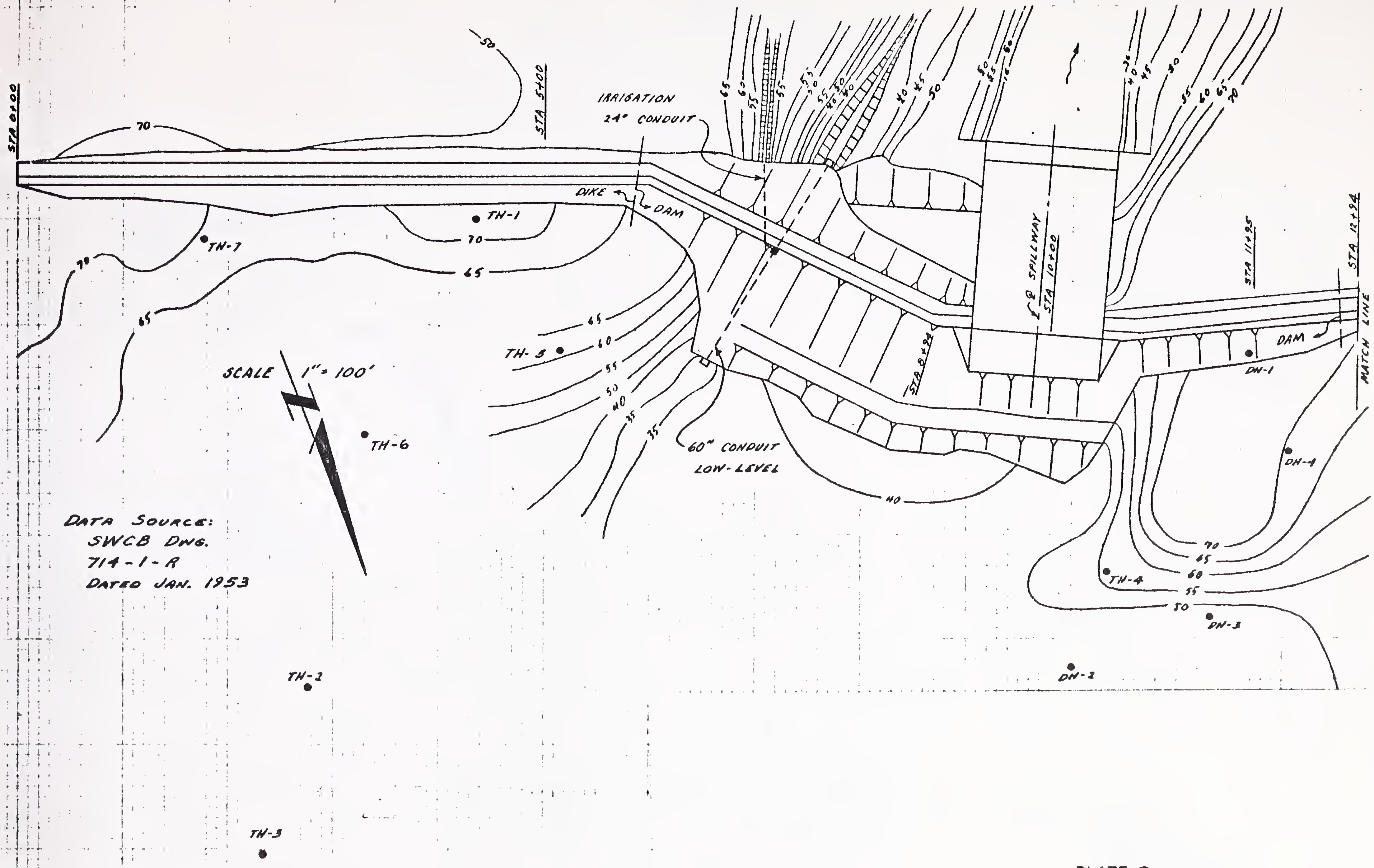


PLATE 2
DRAINAGE MAP
FRENCHMAN DAM

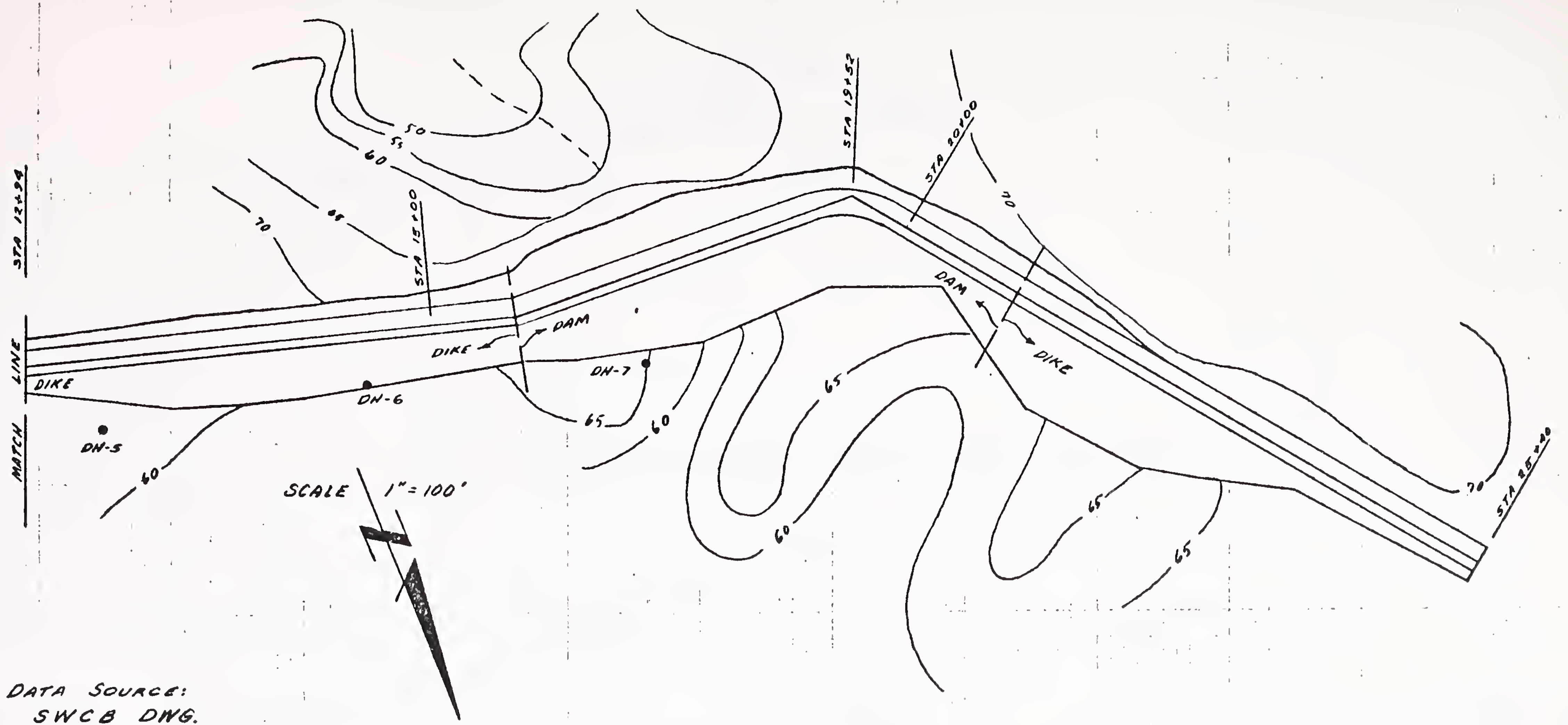
PLAN OF DAM - DIKE EMBANKMENT
(AS RECONSTRUCTED)



DATA SOURCE:
SWCB DWG.
714-1-R
DATED JAN. 1953

PLATE 3
EMBANKMENT PLAN
FRENCHMAN DAM

PLAN OF DAM - DIKE EMBANKMENT

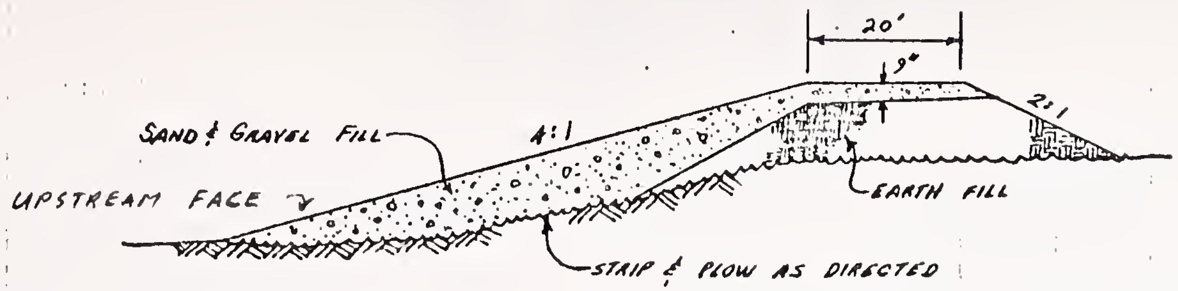


DATA SOURCE:
SWCB DWG.
714-1-R
DATED JAN. 1953

PLATE 34
EMBANKMENT PLAN
FRENCHMAN DAM

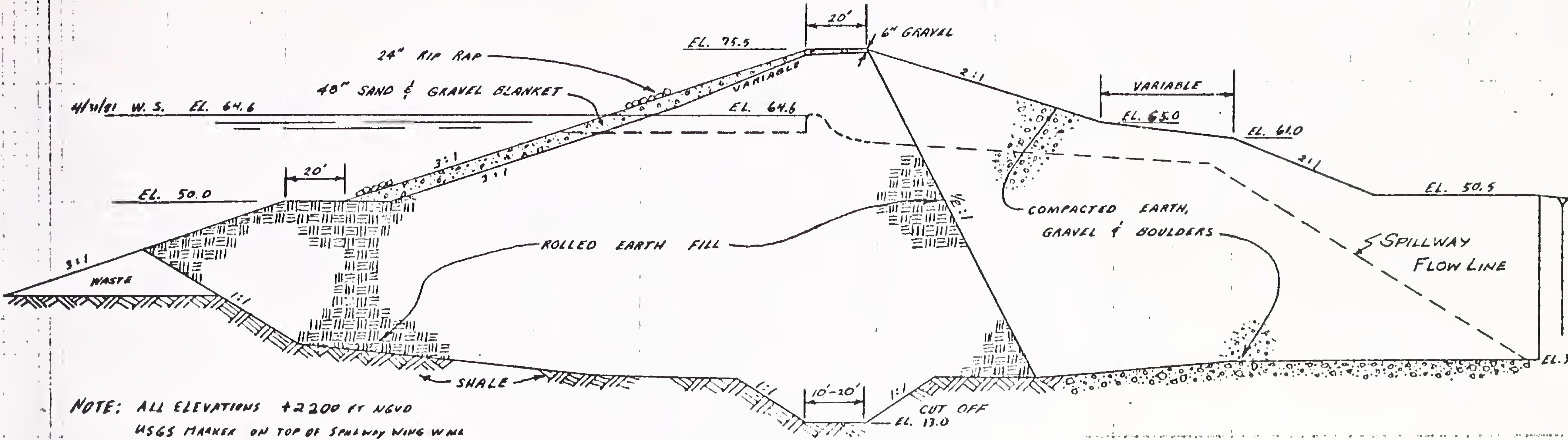
TYPICAL DIKE SECTION

SCALE: 1" = 100'



TYPICAL DAM SECTION AT SPILLWAY

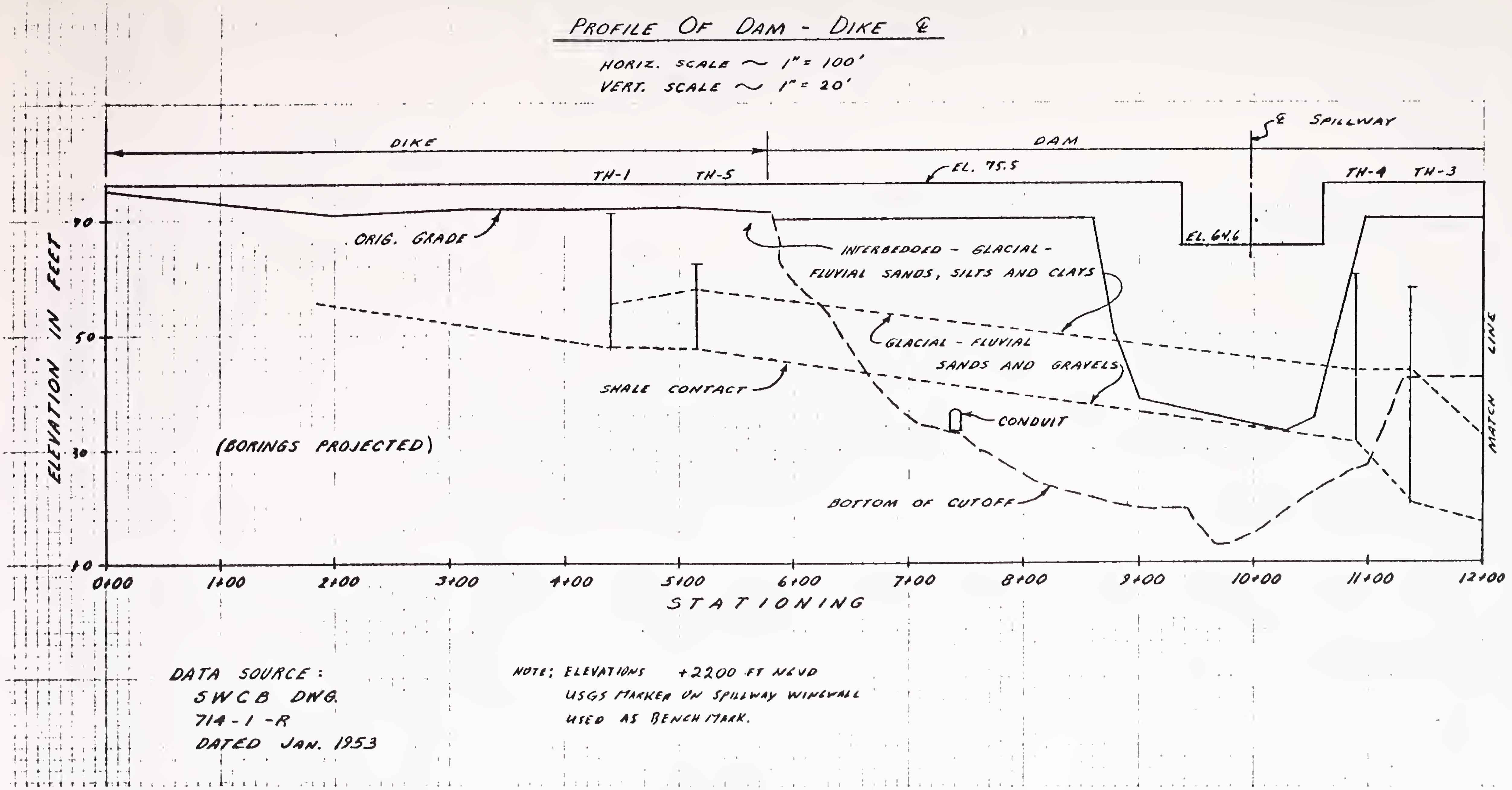
NO SCALE



NOTE: ALL ELEVATIONS +2200 FT NGVD
USGS MARKER ON TOP OF SPILLWAY WING WALL
USED AS BENCHMARK.

DATA SOURCE: SWCB DWG 714-1-R
DATED JAN. 1953

PLATE 4
EMBANKMENT SECTIONS
FRENCHMAN DAM


PROFILE OF DAM - DIKE ℄

HORIZ. SCALE ~ 1" = 100'
VERT. SCALE ~ 1" = 20'

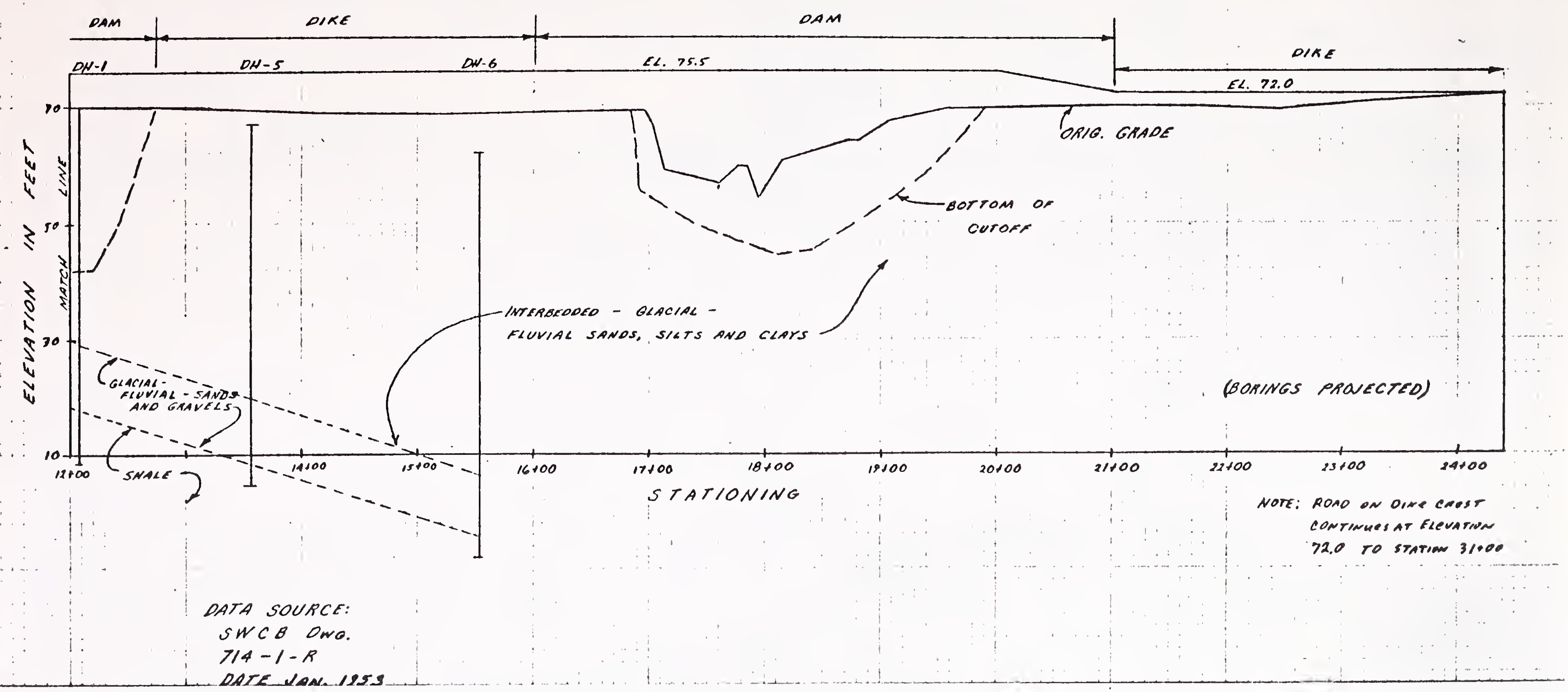
DATA SOURCE:
SWCB DWG.
714-1-R
DATED JAN. 1953

NOTE: ELEVATIONS +2200 FT NGVD
USGS MARKER ON SPILLWAY WINGWALL
USED AS BENCH MARK.

PLATE 5
GEOLOGIC PROFILE
FRENCHMAN DAM

PROFILE OF DAM DIKE ℄

HORIZ. SCALE: 1" = 100'
VERT. SCALE: 1" = 20'



NOTE: ROAD ON DIKE CREST CONTINUES AT ELEVATION 72.0 TO STATION 31+00

DATA SOURCE:
SWCB DWG.
714-1-R
DATE JAN. 1953

PLATE 5A
GEOLOGICAL PROFILE
FRENCHMAN DAM

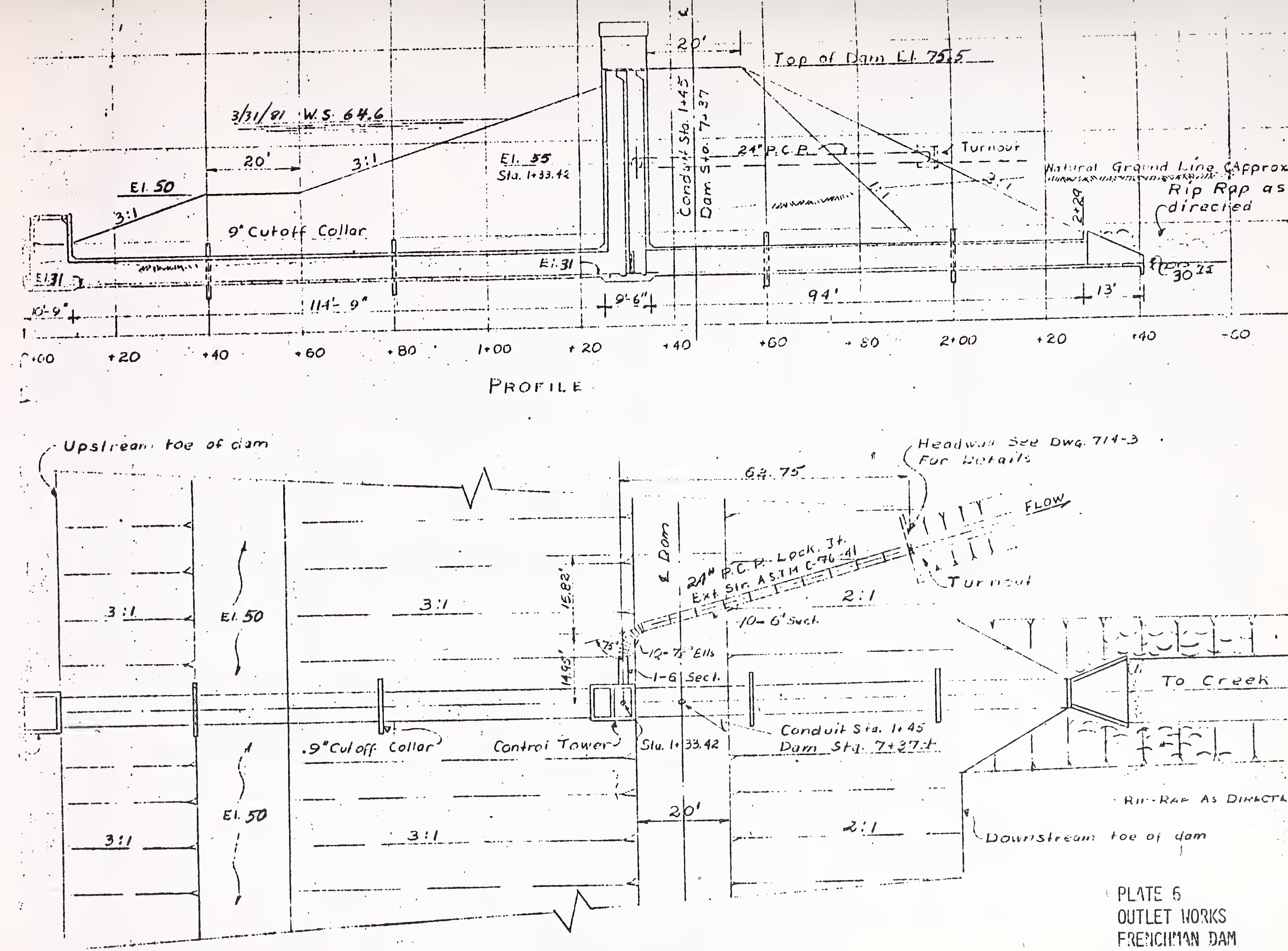
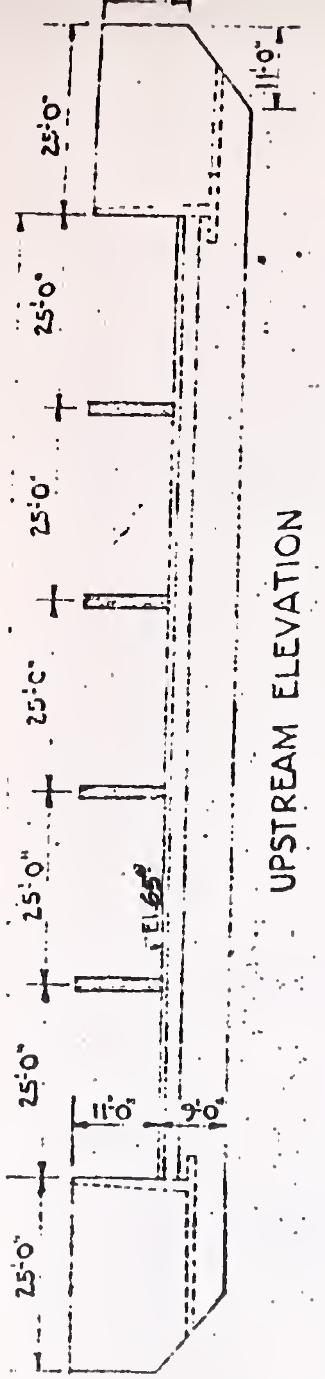
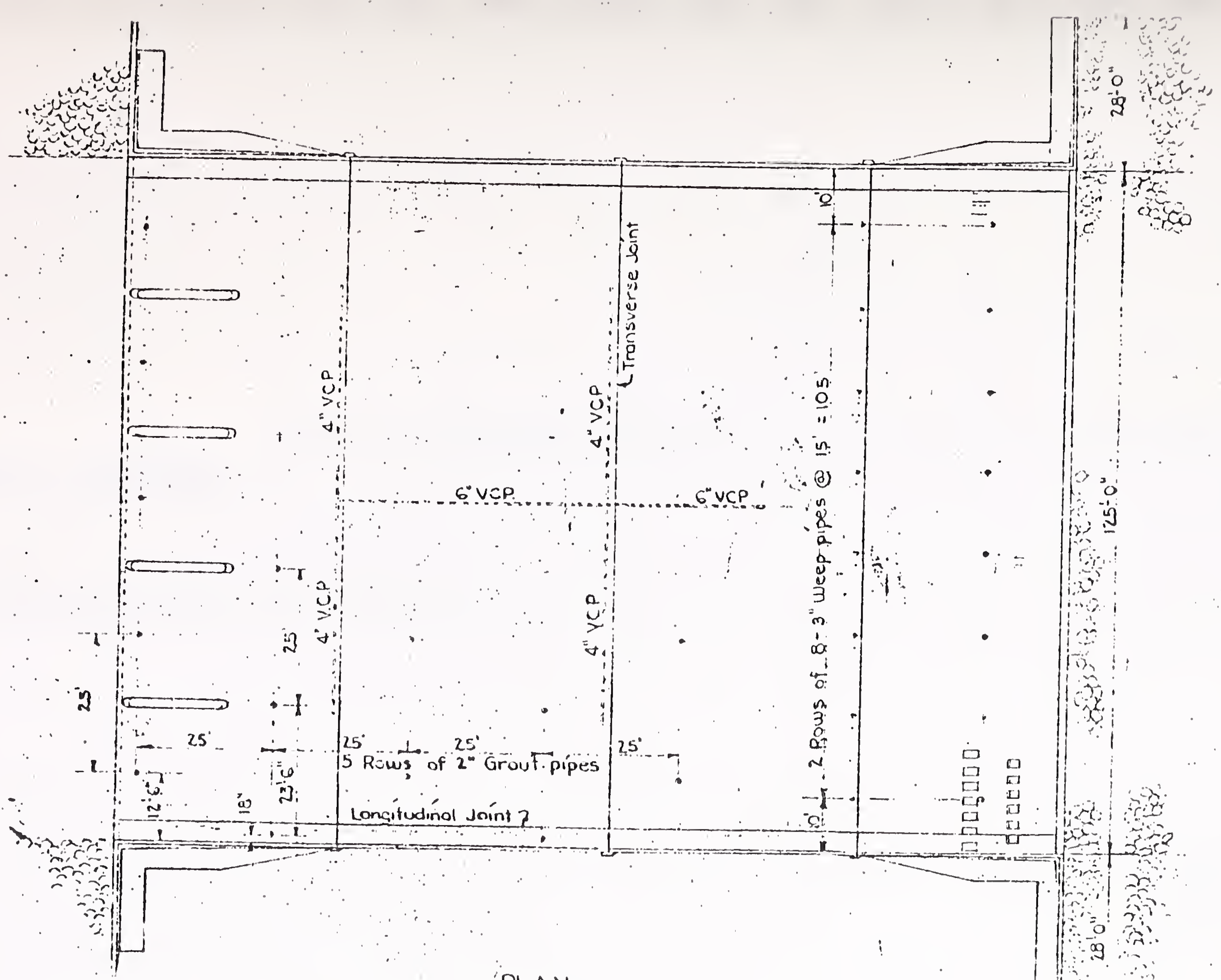


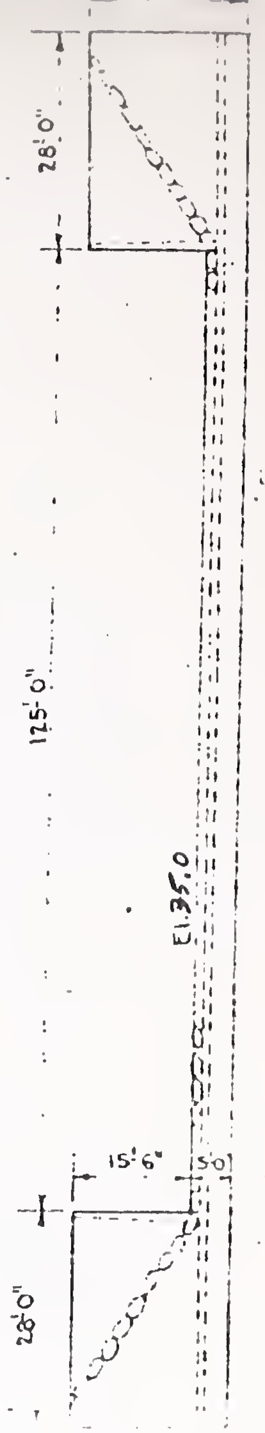
PLATE 6
OUTLET WORKS
FRENCHMAN DAM

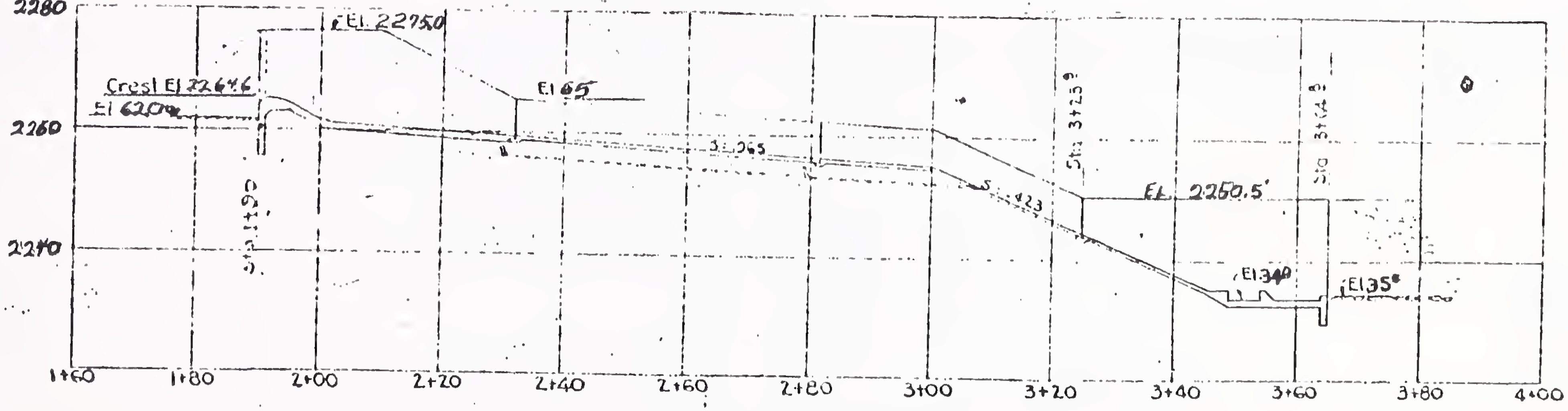


UPSTREAM ELEVATION



PLAN





PROFILE - SPILLWAY

PLATE 7
SPILLWAY
FRENCHMAN DAM

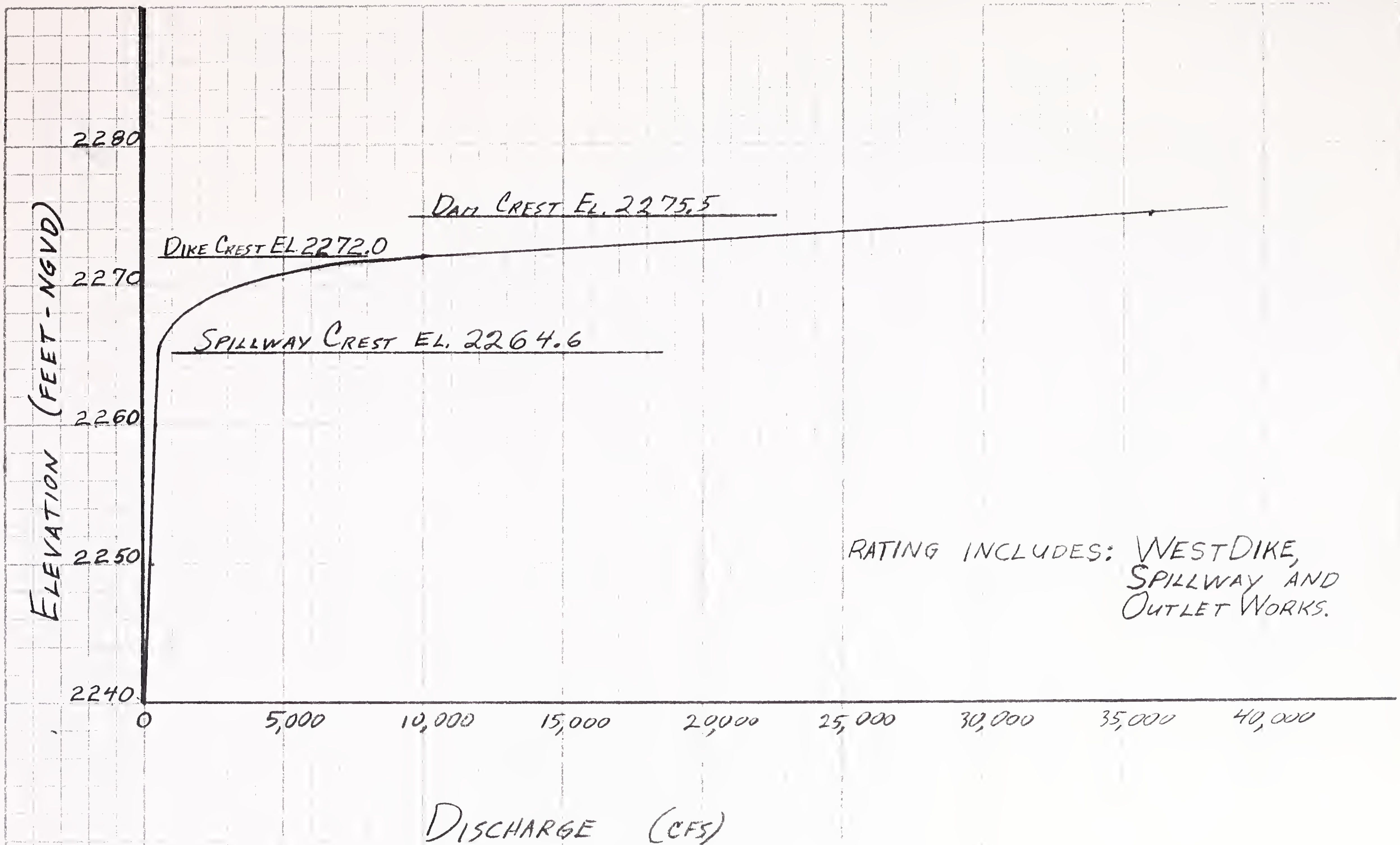


PLATE 8
RATING CURVE
FRENCHMAN DAM

APPENDIX A

DEPARTMENT OF NATURAL RESOURCES
AND CONSERVATION
WATER RESOURCES DIVISION

TED SCHWINDEN GOVERNOR
32 SOUTH EWING

STATE OF MONTANA

(406) 449-2872 ADMINISTRATOR
(406) 449-3962 WATER RIGHTS BUREAU
(406) 449-2872 WATER SCIENCES BUREAU
(406) 449-2864 ENGINEERING BUREAU
(406) 449-2872 WATER PLANNING BUREAU
HELENA, MONTANA 59620

August 11, 1981

Department of the Army
Seattle District, Corps of Engineers
P.O. Box C-3755
Seattle, WA 98124

Attention: Ralph Morrison

Re: Christian, Spring, Sielbach and Associates Dam Safety Investigation on Frenchman Dam (MT-3).

We have reviewed the above referenced final draft report. We concur with the findings and recommendations and find that it satisfies the criteria of the Phase I report.

Minor editorial comments have been discussed with your staff, and we understand these will be incorporated in the final report.

Copies of the final draft report were sent to the Frenchman Water Users Association, who operate the project, but they did not have any comments at the present time.

Thank you for the opportunity to review and comment on the final draft report on the Frenchman Dam.

Sincerely,

Richard L Bondy

Richard L. Bondy, P.E.
Chief, Engineering Bureau

RB:AT:lz

"AN EQUAL OPPORTUNITY EMPLOYER"